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ESSAYS, MONOGRAPHS, AND CASES.

Osteo-Plastic Operations. By B. LANGENBECK, Professor of Surgery in the University of Berlin. Translated and communicated by WILLIAM F. HOLCOMB, M.D.

Osteo-Plastic operations are those which have for their purpose the reparation of defects in bone, or the performing of resection in such a manner that the removed portion may be supplied by a *new deposit* of osseous matter.

The reparation of defects in bone may be effected by various operative methods.

I. BY BRINGING TOGETHER AND UNITING THE BORDERS OR EDGES OF THE FISSURES IN BONE.

The closure of fissures in the hard palate is attempted in this manner.

II. BY TRANSPLANTING A NEIGHBORING PORTION OF BONE TO SUPPLY THE DEFECT.

The moving and *engrafting* of the ossa intermaxillaria into the fissure of the processus alveolaris, in double-cleft palate, as accomplished according to Blandin's method, by *cutting through the vomer;* Gensoul's plan of breaking up the union of the intermaxillary bones with the vomer, and my operation of dividing the *cartilago-triangularis*, illustrate this method. Pirogoff's proposed plan of transplanting the calcaneus to the sawed surface of the tibia, after a previous exarticulation of the

foot and the consolidation of both these bones, belongs also to this class.

III.—THE REUNION OF A FRAGMENT OF THE DETACHED BONE.

The first attempts of this kind were made by Percy, who endeavored to supply defects, occasioned by gun-shot wounds in the lower extremities, by engrafting portions of the tibia of an ox. These experiments failed. Von Walther was more fortunate in replacing a piece of cranial bone, trepanned from a man 36 years of age, as the greatest portion of the bony disk healed, while only a small portion exfoliated. The attempt made later by B. Heine, to reunite an exsected portion of the rib of a dog, terminated just as unfortunately as the experiments of Percy; and there is reason to doubt the correctness of Von Walther's observations, since portions of bone, which are *set into* or engrafted into others, suffer *erosion* from long contact with the normal fluids from the bone or from pus, very similar to the destruction in caries or exfoliation. In many cases where I have used ivory pins for the purpose of uniting pseudo-arthroses, after three weeks' use, even these were found to have sustained a considerable loss of substance. The end which had been in the bone was rough, as if eroded by caries, and had lost even a third of its circumference. In the case related by Von Walther, the portion of bone which was removed by the trepan, was replaced and allowed to remain three months, may have become reduced in size by a similar process. This subject has lately acquired a new, though only a physiological interest, through the researches of Ollier. (See the work "On the Artificial Production of Bone by Means of Transplantation of the Periosteum, and by Osseous Grafts. By L. Ollier. 1859.) This author (v. page 13) engrafted the bones of animals upon those of the same species, (rabbits,) sometimes under the skin of the axilla, and sometimes in cavities formed by the extirpation of a corresponding bone, (os metatarsi;) the transplanted bones continued to live and grow in their new home. On account of the greater vulnerability of the human species, and its slight recuperative power, as well as the impossibility of employing corresponding material, it is impossible to make these experiments in operative surgery. But that it is possible, however, to effect reunion in a bone which has been completely separated from its *bony* connections, provided it remains united to the parent bone by the periosteum, is shown by the following case:

CASE.—*Naso-pharyngeal Polypi; Resection of the Processus Nasalis and the Right Os Nasalis; Extirpation of the Polypi; Replacing and Reunion of the resected Bones.*

A healthy boy, of 18 years, was received into the clinic, in whom

the space behind the soft palate was completely filled by two fibrous polypi. The smaller tumor was attached to the vicinity of the *spina nasalis posterior*; and the larger, near the right tuba eustachii; and from it, a prolongation extended into the right nasal cavity, by which it was completely closed. Respiration was difficult, and considerable hæmorrhage had taken place. As it appeared impossible to remove the tumors either through the nasal cavity, or by division of the soft palate and resection of the palate bones through the mouth, I decided to resect the processus nasalis of the superior maxilla, as I had done before in similar cases. (*Vide* Theo. Billroth on Resection of the "Processus Nasalis." Deutsche Klinik. 1854.) In the former cases I had only resected and removed the processus nasalis of the superior maxilla. But as, in this case, the bone referred to was not driven forward, I had reason to fear the passage to the pharynx made by its removal would not be wide enough to enable me to reach the tumor. As the *permanent* resection of the right nasal bone would leave a proportionate disfiguration, I decided on trying to replace the resected bone. The operation was performed Nov. 3d, 1859. A nearly straight incision was made from the *glabella*, passing downward to the right over the processus nasalis, running to the ala nasi. The *skin*, carefully dissected, was so far separated that the processus nasalis of the superior maxilla, and the whole of the right os nasale, were brought into view, and then the upper border of the right ala nasi was detached from its corresponding connections with the above-mentioned bones. By means of sharp bone forceps, an incision was made from the nasal cartilage along the sutura nasalis to its union with the os frontis; and by a second incision, extending into the sinus maxillaris, the base of the processus nasalis was divided. This incision terminated where the angle of the superior maxilla, below the orbit, joins the os lachrymale. An elevator, introduced into the nasal cavity, was used to raise both bones from their bed, and at the same time the nasal bone separated at its suture with the os frontis, so that the whole, adhering to the periosteum, could be thrown up and held on the forehead. The polypi were then removed. After the bleeding was checked, the BONY FLAP was brought to its former place, and the external wound was closed by silver sutures, (which were *tied* like a thread,) and the nasal cavity carefully plugged with *charpie*. These resected bones were completely detached from the superior maxilla, frontal and left nasal bones, but were held together by periosteum and mucous membrane, and were also joined to the ossa frontis and nasal cavity by a strip, about an inch wide, of periosteum and mucous membrane. For a few days after

the operation, there was considerable swelling of the soft parts covering the wounded bones, which had, however, nearly disappeared on the 18th of November, by the application of cold water compresses. Cicatrization of the soft parts complete; no secretion from the nasal cavity; and the mucous membrane, as far as can be felt by the finger, appears to be healed. Respiration by the nose is entirely free. Pressure of the finger on the resected bones causes no pain. Between the nasal process and the superior maxilla there exists a little tumefaction, but none at the nasal suture. Patient left the bed.

IV.—"PRESERVATION OF THE PERIOSTEUM AND THE SURROUNDING SOFT PARTS."

All surgeons who have resected bones, acknowledge that, in order to have the bone reproduced, it is of the highest importance that the surrounding periosteum be preserved; and all experience demonstrates that the removed portion of bone will be more or less perfectly reproduced in proportion as the periosteum is preserved. As long ago as 1843, I extirpated the entire *ulna*, together with the carious superior extremity, which was much hypertrophied from a chronic traumatic inflammation of long standing. In this case, the *entire* periosteum was preserved. A new ulna was deposited, with its perfectly traceable processes. The movement of the elbow-joint was complete, and the new, but more flattened, olecranon could be felt through the soft parts. In the year 1846, I brought this young man before the meeting of the German Scientific Congress. (See Official Report of the 24th Congress of German Naturalists and Physicians, in Kiel, 1846.) Since that period, a very great number of resections and extirpations of bone have convinced me that, by preserving the periosteum, a perfect reformation, (osteo-genesis,) or reproduction of bone, may be expected with certainty, unless the bone is suffering from *discrasia*. This opinion, formed before 1848, explains why, in the Schleswig-Holstein war, I undertook the resection of the fragments of broken *diaphyses* of bones, fractured by gun-shot wounds—an operation for which I have been greatly blamed, but which, I am thoroughly convinced, will one day take its place in military surgery. In the resections which occur in times of peace, it is very easy to preserve the periosteum which has become thickened, (as in inflammed bones;) impossible, however, when we have to expect long bones which are attacked by tumors. The preservation of the periosteum, in the resection of joints, is inadmissible, (so far as it *can* be preserved,) in case we wish to obtain a movable joint. These operations, according to our former ideas, offer no inducements for us to try to preserve the normal, *thin* periosteum.

Every operation which *maims* the patient is a "*testimonium paupertatis*" for the surgeon.

This reflection always forced itself upon me at each one of the numerous resections of the upper jaw which I have performed, and, nevertheless, (I am ashamed to confess it,) the idea never occurred to me that it might be possible to bring this operation directly into the field of conservative surgery, by detaching the periosteum from the exsected bones and leaving it in connection with the adhering soft parts. The complete extirpation of the superior maxilla, or of half of it, not only deforms the face in a sad manner, but leaves behind a far worse result as regards articulation and deglutition, because the partition between the mouth and nasal cavity falls away. The conservation of this partition I consider as *certainly secured*, if we do not remove the *involucrum palati duri*, but preserve it, detaching it with the periosteum from the hard palate. I even regard it as possible to preserve the periosteum of the facial and orbital surfaces of the superior maxilla, and thus, perhaps, render the disfigurement less noticeable. It is unnecessary to say, however, that when extirpation is performed on account of *cancer*, this is impossible. But this operation is practicable in the majority of *osteo-sarcomatous, fibrous, enchondromatous* and *myeloid* growths of the superior maxillary. The detaching of the periosteum from the superior maxillary bones, the surface of which is so irregular, is difficult and troublesome, and thus additional labor in extirpation will detract considerably from the precision and rapidity of the operation. Further experience will show which incision (through the soft parts) will render the detaching of the periosteum the most convenient. In any case, I would commence the most difficult part of the operation by first making an incision along the lower and outer margin of the gums, and then, by means of a *denuding* instrument, would detach the gum with the periosteum from the bone; then divide the gums along the inner surface of the alveolar process as far as the soft palate, and separate it, *with the periosteum*, from the roof of the mouth. Then the incision of the external soft parts, which should be separated from the bone with the periosteum, should follow. The periosteum of the orbit should also be most carefully preserved; and lastly, the *bones* can be divided in the usual manner. I would finally join the gums and the periosteum of the facial surface to the border of the detached *involucrum palati duri* by means of sutures. The cases in which I have operated in this manner are yet too recent to admit of an opinion as regards the reproduction of bone; nevertheless, I may be allowed to communicate them.

FIRST CASE.—*A large Enchondroma on the under surface of the Palatum Durum—Removal of the Tumor—Preservation of the Bone and the Involucrum Palati Duri—Healed by first Intention.*

W., 27 years of age, of healthy appearance, and, excepting having contracted a primary syphilitic affection five years ago, said he was never sick; in 1857, observed a swelling, of the size of a pea, in the left half of the hard palate, which caused no pain. At first, this increased very slowly; but after a while, and particularly since the fall of that year, it grew very rapidly, softened in several places, and ulcerated near the teeth of the left side. The tumor occupied no longer a small surface, but spread over the entire palatum durum, and pressed everywhere upon the fine, sound teeth of the superior maxilla, and when the jaw was closed it nearly filled up the mouth; it also pushed the soft palate posteriorly towards the basilar portion of the os occipitis. The swelling, which was firm, hard, uneven, and free from pain, was covered by the *involucrum palati duri*, which appeared healthy until near the margin of the alveoli of the left side, where the ulceration existed, through which the probe could be introduced into the substance of the tumor. The probe, and also the acupuncture needle, when passed into the swelling as far as possible, encountered everywhere osseous matter scattered throughout the semi-solid mass.

According to the patient, many small pieces of bone had been thrown off. Whether these belonged to the *palatum durum*, or whether they were ossified portions of the tumor, which had been regarded as enchondromatous, could not be decided with certainty. The entire facial surface of the superior maxilla appeared unchanged, except a small bony tumor the size of a cherry, which was situated on the outside of the alveolar processes above the first molar of the left side. The voice was gone; the articulation indistinct; the respiration was difficult when the mouth was closed; the nasal passages were, nevertheless, perfectly free. On examination with the finger, per nasum, the upper surface of the *palati duri* was found to be smooth, and of normal resistance. But in the left nostril, the *inferior concha* felt rough, and it appeared as if there was a communication between the tumor and the bottom of the nasal cavity; as formerly, by pressure on the tumor in the mouth, blood flowed from the left nostril.

According to the first impression which the disease made upon many physicians, (and on myself also,) who examined the patient, we were led to regard the resection of the left half of the *superior maxilla*, and the entire *palatum durum*, as unavoidable; and the young man had decided to have the operation performed in the Clinic, but the sound

and firm teeth, as well as the normal condition of the nasal cavity, warranted (after repeated examinations) the hope that such disfiguration might be avoided. The operation was performed Nov. 14, 1859. A firm incision along the inner margin of the teeth of the left superior maxilla divided the *involucrum palati duri*, together with the *periosteum*, which were now loosened partly by means of the raspatory, and partly with the knife.

This part of the operation was very difficult in the vicinity of the ulcerated opening, but became easier in proportion as I advanced posteriorly, and succeeded so completely that both membranes terminating in the soft palate hung down like a flap of skin, and the entire swelling was brought into view. The periosteal surface of this flap was smooth throughout, excepting only in the vicinity of the ulceration, where some fragments of the tumor remained, which were carefully removed. The tumor itself was now (by means of a sharp chisel) separated from the *palatum durum*. Some isolated inequalities of the bony palate (which appeared entirely free from disease) were then removed, and I replaced the flap directly against the bony surface, and fastened it to the gums by a firm suture. A moistened sponge was inserted into the mouth, and held in place against the palate of the tongue. The tumor appeared to be purely enchondromatous, with an abundance of bony scales scattered through it. The whole wound healed by first intention, without the occurrence of the least accident. The flap adhered firmly and smoothly to the bony palate, except at two points in the centre, where it had not united to the bone, without, however, any suppuration having occurred. If a superficial exfoliation should follow this operation, requiring removal, we have the proof that it is possible, even in the resection of the superior maxilla, to preserve the periosteum and *involucrum palati*, and reunite them to the gums, as was done in this case.

Second Case.—*Exostosis of the Processus Alveolaris—Resection of the same, with the preservation of the Gums, Involucrum Palati Duri, and Periosteum.*

H. W., 7½ years old, a boy of very anæmic appearance, was brought to be operated on in the Clinic Nov. 14th, 1859. The enlargement of the *processus alveolaris*, of three years' growth, extended from the gap occasioned by the removal of the upper posterior molar of the right side, to the second incisor of the left side, and extended outward towards the right *ala nasi*. The tumor was about the size of an English walnut, and projected equally inward (towards the hard palate) and outward, so that the upper lip and ala nasi appeared

slightly pushed forward. The tumor is hard as bone, painless, except on firm *pressure*, when the pain is so great as to prevent a faithful examination. It was diagnosticated as hypertrophy of the medullary substance of the bone.

OPERATION.—An incision was made through the gum, near the *processus alveolaris*, from the superior posterior right molar to the second superior incisor of the left side, which had been previously extracted. A similar incision was made on the inner margin of the *processus alveolaris*, through the *involucrum palati duri*. The integuments of the tumor, together with the periosteum, were detached without serious difficulty, by means of a raspatory. The bone was then cut out with bone nippers, in a triangular form, the base looking downward. The second incision crushed the thin plates of the alveolar processes. At this juncture a small, smooth bony substance, about the size and form of a musket-ball, sprang out of the opening. The soft coverings of the alveolar processes were now brought into place, and the edges of the wound exactly joined by a suture. During the first days following the operation only a slight swelling was observable, and the immediate healing of the wound seemed certain. On the fourth day, while the patient was feeling perfectly well, there appeared (in consequence, probably, of some mental agitation,) an unimportant arterial hæmorrhage from the wound. The bleeding ceased after removing the sutures, and syringing the wound with cold water. It returned, however, the following day, and was arrested by the application of a tampon of tannin. On November 21st it reappeared; small pellets of lint, wet in tinct. ferri sesquichloridi, were pushed into the cavity, and effectually checked the hæmorrhage. Previous to the first bleeding, the edges of the gums and of the involucrum palati duri came so closely together that the defect in the bone was completely covered; only the teeth appeared to be wanting. Notwithstanding the union was destroyed by the hæmorrhage, yet I hope to be able to repair the defect in the bone at some future period. Since non-malignant tumors of the alveolar process of the superior and inferior maxillary bones very often occur, and as, until now, the soft parts covering them have always been removed *with the tumors*, therefore I regard this sub-periosteal resection, which may be resorted to in the majority of these cases, as a real progress in this operation.

On November 15th, 1859, this case prompted me to try to detach the periosteum, and also the *involucrum palati duri*, in the total extirpation of the right superior maxilla of a boy, 14 years of age. The attempt failed, the mouth and pharynx being nearly filled by this

fibrous tumor of the superior maxilla, which had been previously, and for a long time, treated by caustics, in the hope of destroying it. This cauterization was carried on with great energy, and by means of some caustic unknown to me. At the time the boy was received into the Clinic, on that part of the tumor which protruded from beneath the upper lip there was still a suppurating surface, and the *involucrum palati duri* appeared to be degenerated into an indurated, granulating mass. The soft parts immediately covering the *superior maxilla* had become so friable, in consequence of the long-continued suppuration, that they crumbled into pieces as I attempted to detach them from the bones. The covering of the *palatum durum* and the gums, together with the periosteum, should have been *detached* from the bones, but I only succeeded in *detaching* a large portion which covered the facial surface of the bone. As regards the reproduction of the bone in this case, I shall report at a future period.

V.—Transplantation of the Periosteum upon Defects in Bone.

The experiments of Ollier upon animals (rabbits) have greatly enlightened us in regard to the *power of the periosteum in the reproduction of bone.* He separated flaps of periosteum from the tibia, in such a manner that they remained attached to the bone only by a small strip, and inserted the free end between the muscles of the limb. After a comparatively short time, an *exostosis* had sprung from the flap thus transplanted, the growth of which did not cease, even when, a few days after the transplantation, the strip connecting it to the parent bone was divided. So active was the *independent power* in the periosteum of *forming bone*, that when flaps of it were entirely detached from the tibia, and inserted into the axilla of the same animal, or of another of the same species, it continued to produce bone. To what extent these observations may be applicable in operative surgery experience must determine. *A priori*, we should expect that *human periosteum* will perform its functions as well, when it can be transplanted under as favorable circumstances, as in the cases of Ollier; that is, if we can convey to the living tissues detached periosteum, before it has lost its temperature and natural vitality, and insure immediate reunion of the wound. My first experiment was made by transplanting the *pericranium* (from the os frontis) to the *nose*, to reproduce the ossa nasalia, which had been completely destroyed by disease. Notwithstanding it was evident to me that this experiment, carried on as circumstances required it to be, would be regarded as *unphysiological*, yet that could not deter me from making it, since no unfortunate result could occur to the patient. I can form no opinion

as to the termination, yet I do not hesitate to communicate at this time the principal features of the operation, at the same time, however, calling attention to the unfavorable circumstances under which it was necessarily performed.

CASE.—MRS. L., 40 years of age, was received into the Clinic at the commencement of the present session, (1859.) More than two years ago an ozœna developed itself, which led, on the one hand, to a perforation of the hard palate; and, on the other, to an entire loss of the bones of the nose, conchæ and septum narium. In consequence of this destruction, the bridge of the nose was completely sunken, and the external uninjured soft parts of the nose were drawn back against the nasal processes of the superior maxilla. Notwithstanding the decided denial of the patient that she had had a primary affection, yet the uneven surface of the cranium, and the means employed before her admission into the Clinic, authorized the conclusion that the destruction of the bones was caused by *syphilis*. A purulent secretion from the mucous membrane of the fauces was arrested by four weeks' treatment with the iodide of potassium. I wished to defer the operation until spring, but was obliged to yield to the pressing solicitations of my patient, and the operation was performed Nov. 17, 1859. The soft parts of the nose were divided by a semicircular or U incision, (or rather in the form of a horse-shoe,) extending from the processus nasalis of the superior maxilla over the nasal cartilage, from one ala nasi to the other, opening completely into the nasal cavity—separating the lower from the upper portion. The point of the nose was then drawn downward and forward, in such a manner that the *tip* nearly touched the lip. Into the wound, thus made, a similarly shaped flap from the forehead was transplanted, whose pedicle or nourishing point was near the inner corner of the right eye, the borders of which were united to the edges of the nasal wound by silver sutures. When I formed the flap from the forehead, I cut, not only through the *skin*, but through the PERICRANIUM to the bone, and the whole together was then separated from the os frontis, by means of a raspatory. This operation differed from others which I have performed for repairing defects of the nose, only in the fact that the *periosteum was detached with the skin*, and formed the *base* of the flap which was transplanted into the space where the nasal bones were wanting. Afterwards, the edges of the wound in the forehead were brought together as much as possible by two sutures, the denuded portion of the os frontis covered with lint, the nasal cavity filled with charpie, and the nose covered with a cold-water compress. I will only

state concerning the subsequent history of this case, that to-day, (Nov. 22,) five days after the operation, the *turgescence* and *swelling* of the *rose-colored* flap are much more marked than I have observed in my former cases. The edges of the wound are perfectly healed at nearly all points, only here and there a superficial suppuration. The defect in this operation is, according to my idea, that the periosteal surface of the flap, twisted to cover the opening in the nose, will be in constant contact with the current of air from the nostrils, and as a natural result, must suppurate and granulate. Whether the pericranium remains capable of producing bone under these conditions, seems very doubtful. The denuding of the os frontis, and the possible superficial exfoliation of the same, would hardly be thought of any account, if the design of the operation is thereby accomplished. In cases of complete destruction of the nose, the chances of this operation would be far more favorable. We could cut the skin (surrounding the nasal defect) to the bone, loosen it with the periosteum, and twist it over so that the epidermis would be turned towards the nasal cavity, which would leave the periosteal surface looking upward. *Upon this surface,* for a basis, a flap of skin and periosteum could be transplanted from the forehead, and in this manner the *pericranium* of the frontal flap would lie on the *periosteum* of the facial flap; that is, two periosteal surfaces would be together, and thus render the chances for bony deposit much more favorable. I have frequently, when supplying defects in the nose by frontal flaps, used the surrounding skin in the manner just cited, (but without the periosteum,) to form a lining for the other flaps, particularly, as in this manner I prevented the adhering of the nasal surfaces, which so easily occurs in these operations.

(APPENDIX.)

BERLIN, *January* 31*st*, 1860.

Having seen the operations referred to in this paper, and observed the patients, I am able to give testimony in regard to them. The young man from whom the fibrous polypi were removed from the posterior nares, *via* an opening made by the resection of the right nasal bone and the processus nasalis of the right superior maxilla, left the Clinic perfectly healed. No exfoliation occurred, and only for a few days was there a discharge near the lachrymal sac. The bony union was complete and firm, when I last saw it, about a fortnight since. No irregularity of the bone or mucous membrane could be felt in the nares.

In case 1st, under division 4th, (enchondroma of the under surface

of the palatum durum,) there was a most favorable result. The gums and involucrum palati duri healed to the bone, and no exfoliation took place. The cure is complete.

The boy from whom was resected the processus alveolaris went directly to the country, and died (as was communicated by letter) one week after the operation, from peritonitis. No post-mortem was made.

In case 1st, division 5th, in which there was a *transplantation* of the *pericranium*, to supply a defect in the nose, a most satisfactory result has followed. There was complete union by first intention. There was no morbid secretion from the under (pericranial) surface of the flap, which was greatly feared would be troublesome; but this surface seemed to take on the character of mucous membrane. The apprehended exfoliation of the os frontis did not take place, free granulations having quickly sprung directly from the bone, so that now only a small spot remains uncovered by new skin. In fact, Prof. Langenbeck says it has cicatrized as soon as in the cases where the pericranium was left. The nose feels firm, and has a regular form. A small portion of the flap (which was removed in order to raise the nose up a little) was examined under the microscope, and found to contain an abundance of osseous and cartilaginous cells. Several other osteo-plastic operations have been performed since the above paper was written, the history of which I will endeavor to communicate at a later period. W. F. H.

Lectures on Displacements of the Uterus. By E. R. PEASLEE, M.D., LL.D., Professor of Obstetrics and Diseases of Women and Children in the New York Medical College.

(Continued from last No. of the MONTHLY.)

LECTURE No. II.

GENTLEMEN—In the preceding lecture I have spoken of the structure of the uterus, its normal position and relations, and the agencies maintaining it in position; and in general, also, of the causes of uterine displacements, their symptoms, the methods of recognizing them, and their prognosis. I shall to-day speak in a general way of certain means adopted in the treatment of this class of diseases; and also call your attention to the nervous endowments of the uterus, as explanatory of the manifold symptoms already enumerated.

I. The general indications in the treatment of uterine displacements are:

1st. To replace the uterus.

2nd. To maintain it in its normal position by such aids as may be either temporarily or permanently required.

The former of these objects is accomplished by manipulations, either alone or combined with the use of instruments; the latter, by various means, among which the use of astringents *per vaginam*, and of mechanical supports, are most prominent. And these two classes of remedial means will next be considered.

A. Of *astringents*, the tannic acid, alum, sulphate of zinc or copper, nitrate of silver; or infusions of vegetable substances containing the first, as oak-bark, nutgalls, matico, &c., are most commonly used. All these are used most frequently as vaginal injections, and therefore in solution in water; though they may also be used to advantage in the form of suppositories, or ointment, or of powder. All of them are also used in several other forms of uterine disease.

Some writers, however, object *in toto* to the application of astringents *per vaginam;* though such are generally opposed especially to astringent vaginal injections. Dr. Hamilton maintained that the use of strong astringent injections is injurious, and may be positively dangerous; since the irritability of the vaginal mucous membrane varies in different women, and at different times in the same woman. Of course it is admitted that an injection may be strong enough to do more harm than good in any case. Experience shows what the average strength should be; and also, that we should begin with a weak and proceed to a stronger application. But Dr. Hamilton also thinks that astringent injections are more apt to injure the uterus than the vagina itself; and asserts that most of the many cases of chronic enlargement of the uterus he had been called upon to treat were produced by their use.

Of course, astringents may be so used in some cases as to produce this result. But we have only to be aware of this fact to be able to guard against it. They can produce chronic enlargement of the uterus only by first producing inflammation; and this effect we ought at once to detect, and then to remove the cause. Finally, Dr. Hamilton asserts that a sudden suppression of an habitual vaginal discharge by the use of astringents is often "followed by distressing headache, obstinate inflammation of the eyes, or eruptions on the face."*

* Practical Observations, p. 17.

But, admitting that all the preceding consequences may result from the indiscriminate use of astringent vaginal injections, they will often be found to be very beneficial, if used in accordance with the following directions:

1. Withhold them entirely if there is any inflammation, or even much congestion of the vagina or the uterus.

2. Use them of the proper strength, beginning with a weak application.

3. In case of a profuse discharge, never check it suddenly, by their use.

4. Discontinue the application, if any bad effect ensues from it.

Used with these precautions, I regard astringent vaginal applications, in the various ways enumerated, as very valuable aids in the treatment of the displacements under consideration, as well as of several other uterine diseases; and I shall have occasion, therefore, to recommend them further on.

FIG. 2.

I have insisted on beginning with a weak application. I have been in the habit, on first prescribing an astringent injection, to direct the patient to mix a portion of the whole amount prescribed (say one-fourth) with as much water, and use that first; then mix another portion with half as much water; and next apply the full strength. An ounce of the astringent solution is sufficient for each application, if properly applied. There is no need of one half pint to a pint, as is sometimes directed. It should be used two or three times daily, and applied *cold*. These injections are, however, too often ineffectual, from a wrong method of administration. It is not enough to make your prescription, and tell the patient to use it as an injection. She must be told what sort of an instrument to obtain, and how to use it.

The best vaginal syringe is the "India-rubber Vaginal Syringe, manufactured by the Beacon Dam Company." It is made of vulcanized gum-elastic, is not acted on by acids, is strong, light, and elegant, and of the best form. There are three sizes of this instrument, and the accompanying cut gives an idea of its form—being one-third size linear. A glass instrument of the same form is of course less expensive, and answers very well as a substitute. The instrument being

selected, the patient is to be instructed to use first an injection of cold water, (half pint or more,*) and then apply the astringent injection while in a recumbent position, with the pelvis slightly elevated; using but a single syringeful, but retaining the instrument two or three minutes, at the same time preventing the escape of the fluid from the vagina, so far as may be. If water is not previously used as just advised, the secretion, coagulated by the astringent, accumulates in the vagina, and produces irritation; or at least protects the vaginal membrane from the contact of the astringent, and thus entirely defeats the object of its administration.

Astringent suppositories may also be applied by the patient herself; but in the form of powders the application must be made by the practitioner, through the speculum.

B. *Mechanical supports* may be arranged in two classes—the *external* and the *internal*.

The *external* include a great variety of bandages, most of which are termed abdominal and utero-abdominal supporters. The idea, however, of supporting the uterus (except during pregnancy) by any kind of bandage applied around the abdomen or pelvis, while this organ does not rise to the level of the superior plane of the bony pelvis, as I have shown, (Fig. 1.) is simply absurd. The term "utero-abdominal supporter" is therefore a misnomer, and only calculated to delude the ignorant. Abdominal supporters are useful in cases of relaxation of the abdominal walls, during pregnancy, or otherwise, and they will sometimes, by their pressure, either anteriorly or posteriorly, relieve some symptoms produced by a uterine displacement. So far, then, they are of real value. But on the other hand, they can never in the least tend to restore a displaced uterus to its normal position; and they may, by their indirect pressure upon it, insure a displacement in cases with a mere predisposition thereto. They must therefore be used with extreme caution in the displacements to be considered, provided other complications render their use expedient.

The *internal*, or intra-vaginal mechanical supports, include a great variety of appliances to support the uterus after it is reduced to its normal position, and to which the general term "pessary" has been applied. Some, however, object to pessaries in all cases, though they use a ball of lint, soaked in an astringent solution, instead. Such a ball, however, when used to support the uterus, is simply a medicated pessary. So, also, is a muslin bag, filled with an astringent powder,

* The same vaginal syringe may be used for this purpose.

when used for a similar purpose. The ancients used a variety of vegetable substances, and other matters too disgusting to be named, as pessaries. I shall have occasion to recommend the two forms of medicated pessary just mentioned in another connection.

But the word "pessary" is usually applied to an instrument made of wood, ivory, glass, gum-elastic, gutta-percha, cork, sponge, or some metal that is not liable to oxydation; of a circular or oval outline; sometimes discoid, and perforated in the centre; sometimes in the form of a simple ring, or of a globe, or an ovoid—and which is introduced into the vagina to support the uterus, as before explained. Within a few years some practitioners have also used instruments passing partly into the cavity of the uterus, in the treatment of uterine displacements, and these may be termed *intra-uterine* pessaries. These are, however, recommended only in cases of anteflexion or of retroflexion, and I shall speak of them in connection with these two displacements. We should, however, form a definite idea of the actual value of intra-vaginal pessaries in this connection.

I would as soon say I would never use a splint in surgical practice, as that I would never use a pessary in the treatment of uterine displacements; though they are not often, like splints, quite indispensable to the treatment of the case. They are, however, in many cases the best remedy, if used with the proper restrictions, and therefore should be preferred to all other means.

Among the high authorities opposed to the use of pessaries are Dr. Hamilton, before quoted, Dr. Rigby, and the late Prof. Dieffenbach; and the following is the sum of their objections to them:

1. They are indelicate for the patient to wear.

2. They cause a (sometimes even putrid) vaginal discharge, by irritating the vaginal mucous membrane.

3. They are of no use, or even fall out, if too small; and dilate the vagina if too large.

4. They cause ulceration and fungous growths, and ultimate contraction of the vagina.

5. They produce constipation and irritation of the bladder.

6. They subject the patient for life to the charge of the medical attendant.

7. They may become incrusted by calcareous matter, and have to be broken before they can be removed; or may pass, by ulceration, through from the vagina into the bladder or rectum.

If but a small part of these effects of the use of pessaries be unavoidable, very few practitioners certainly would have the hardihood

to use them, even in desperate cases. But this is by no means the fact; and to denounce an instrument because it may be made to do mischief is hardly philosophical. The question should be, Can the instrument be made to do good? and if so, under what conditions, and with what restrictions? And, as furnishing a reply to the latter question, I should say that the following rules should, in practice, be adopted:

1. Pessaries are not to be used if there be irritation or inflammation of the vagina or the cervix uteri, or any other organic disease of the latter. If neither of these exist, the question of their use may be considered.

2. Their size must be precisely adapted to the cases requiring them.

3. Watch the patient after the introduction of the instrument, and remove it if any occasion for so doing arise.

4. Examinations should subsequently be made at proper intervals to ascertain if any mischievous effects are being produced, in which case the instrument is to be removed.

5. The woman must be taught to keep the instrument cleansed by daily vaginal injections of water or weak soap-suds. I once removed a glass pessary which had remained fourteen months in the vagina. It had not caused the least irritation, though the physician who introduced it had not instructed the patient to take the precaution I have just inculcated.

6. Remove the instrument occasionally, (once a month, at least,) to make sure that it remains in good condition; reapplying it if it does so remain, or a smaller one, if such will now answer.

I consider the question of the delicacy of wearing a pessary as too trivial for serious consideration. If notions of delicacy alone were to control us, we should never even ascertain the existence of these displacements by any examination, nor advise any local treatment at all if they were conjectured or discovered.

Used with the precautions above mentioned, and in cases requiring mechanical support, I consider pessaries temporarily used to be of great value; and I shall here add some remarks upon their composition and their forms.

In order to answer the conditions before specified, a pessary should be (1) as light as possible; (2) made of a material which will retain a smooth surface, and therefore not be acted upon by the uterine or vaginal fluids; and (3) be of a form best adapted to the vaginal walls, and causing the least possible pressure consistent with securing the object for which it is used.

The *form* which insures the greatest degree of lightness is the ring,

and I therefore prefer it. If the material be glass, it is liable, unless quite thick and heavy, to fracture. But the ring pessary may be made of a thin plate of silver or gold, first soldered in the form of a tube, and then curved so as to form a circle of the proper diameter. A solid ring of ivory may answer, but is heavy, and ivory is objectionable as a material. Gum-elastic renders the vaginal discharges intolerably fœtid. Gutta percha is not, however, liable to this objection, (if used in its usual purity,) and I prefer, for most purposes, the pessary I have so often used before you, consisting of a ring, $2\frac{1}{4}$ inches (more or less) in diameter, made of a piece of watch-spring, which is completely covered by gutta percha, so as to make the ring about four lines thick. This ring pessary has the advantage of being light, and can be made to maintain a circular or elliptical form at pleasure. Besides, it is not acted upon by the fluids in contact with it, if ordinary care is exercised to keep it clean. A patient of mine retained one eleven months —though contrary to my directions—and at the end of that time its surface had not changed in the least. Their size will vary from $1\frac{1}{2}$ to 3 inches in diameter, in different cases. A simple ring of tin is also a very serviceable, and a cheaper pessary; and being quite flexible, and rather firm, it may be bent into any required form before its introduction, and which it will afterwards retain. A ring pessary, properly adjusted, will answer all the requirements of this class of instruments, in almost every case, except when a globe pessary is needed.

The pessary just described is used to retain the uterus after it is replaced; the *globe* pessary is an important aid, in some cases, in replacing and then retaining the uterus. It finds its peculiar value in some cases of prolapsus uteri, with adhesions of this organ, as will be seen. It is simply a hollow sphere, or is sometimes shaped like an egg, and made of a very thin and light plate of gold, or of silver. A solid ball of any substance is objectionable, on account of its weight.

Of *stem pessaries* I have little to say. They are kept in the vagina by some external apparatus; which should always be avoided, if possible, as very inconvenient to the patient; and I have not, of late, met with any case in which I could not accomplish all that this form of instrument promises, by the use of the forms already described. For it is only in prolapsus that the stem pessary pretends to any superior merit. I should, however, add, that the stem pessary may be the best in certain complications with prolapsus, hereafter to be specified. Sponge pessaries become intolerably offensive, even in a few hours, and cause much irritation of the vaginal membrane. Cork is also liable to the same objection in a less degree. Of late, therefore, I have confined

myself, with very rare exceptions, to the ring pessary, made of gutta percha or metal, and the globe pessary of metal, as before described; with such medicated pessaries as will be specified further on. I long ago laid aside the gum-elastic bags, introduced into the vagina in a collapsed state, and subsequently inflated; they becoming intolerable from the odor they impart to the vaginal secretion.

II. In regard to the *nervous endowments* of the uterus, quite diverse opinions have been recently maintained. Dr. Robert Lee published the results of his investigations in 1842, (see Philosophical Transactions for that year,) and maintained that an extensive nervous network covers the entire uterus; and which is derived from the hypogastric and spermatic plexuses, and forms vesical and vaginal ganglia, and anterior and posterior sub-peritoneal ganglia and plexuses. He also maintained that this great system of nerves enlarges during gestation, and returns again to its former condition after parturition. Most obstetricians adopted Dr. Lee's ideas on this subject till within the last few years. But Dr. Lee did not verify his dissections by the use of the microscope; and Dr. Snow Beck, applying that test, has come to the conclusion that the uterus is, on the contrary, not abundantly supplied with nerves. I have no difficulty in believing that Dr. Beck is in this correct; for, in addition to his positive demonstrations, the uterus gives no evidence of a very high degree of innervation either in its physiological condition or its pathological states. That the nerves are, however, enlarged during gestation, is certainly in the highest degree probable. All our certain knowledge, however, up to the present time, respecting the sources of the nerves distributed to the uterus and its appendages, may be expressed in a rapid and general manner as follows:

The genital organs of the human female derive their spinal nerves from the lumbar and the sacral plexuses; and their sympathetic branches from the spermatic and the inferior hypogastric (or pelvic) plexuses.

A. The *spinal nerves* from the lumbar plexus are as follows: The scrotal branch of the *ilio-scrotal* nerve (as it is called in the male) is distributed to the round ligaments and the labia majora; while its abdominal branch goes in part to the mons veneris and to the groin. A branch of the *ilio-inguinal* nerve also communicates with the latter, and proceeds to the same parts. The genital branch of the *genito-crural* nerve is also distributed to the round ligaments and the labia majora, and to the skin of the groin. Other branches from the lumbar plexus are distributed to the integuments and muscles of the thigh, and the internal saphena branch of the femoral (or anterior

crural) nerve, even to the foot. These facts account for the reflex pain often felt by patients with affections of the uterus, in parts at a distance, and especially in the lower extremities.

The following are the *spinal* nerves from the *sacral plexus:* The *visceral nerves* ascend on the sides of the vagina, rectum, and bladder, and the 3d and 4th sacral nerves give off branches to the uterus. The superior branch of the *internal pudic* nerve goes mainly to the clitoris; its perineal branch to the vulva and the perineum. The perineal cutaneous branch of the lesser ischiatic nerve also supplies the vulva.

B. The *sympathetic* nerve-fibres are derived from the following sources: The *spermatic plexus* gives off branches to the round ligaments, the ovaries, the Fallopian tubes, and the uterus itself. The *inferior hypogastric* (or pelvic) *plexus* gives off branches to all the organs in the pelvis. The *uterine nerves* come off above the sacral nerves, and thus penetrate the substance of the whole of the uterus in company with its arteries. They therefore consist mostly of sympathetic fibres. For you are aware that the sympathetic nerves, so called, contain also some coarse (or spinal-nerve) fibres. On the other hand, the nerves to the vagina from the vaginal plexus (an offset from the pelvic) contain many coarse, (or spinal,) and but few fine (or sympathetic) fibres. This accounts for the greater sensibility of the latter portion of the genital apparatus.

A recapitulation of the preceding facts gives the following result:

1. The *uterus* is supplied with *spinal* nerve-fibres from the sacral plexus, and with *sympathetic* fibres from the spermatic and the pelvic plexuses. As the visceral nerves are also distributed to the other organs of the pelvis, and other branches from the sacral plexus are sent to the gluteal and sacral region, and to the lower extremity, we should expect a wide range of reflex sensations developed in the various uterine affections. Moreover, this expectation is further enhanced by the fact that the pelvic plexus also gives off branches to the other organs in the pelvis, as well as to the uterus. Reaching the uterus between the two layers of the broad ligament, its nerves are distributed from the fundus and body to the neck, and to the latter part most abundantly. More branches are also sent to its posterior than to its anterior half, and hence the former is its most sensitive portion. Besides, the body of this organ is not so highly sensitive in its normal condition as the neck, from the greater proportion in its nerves of the fine fibres.

2. The *appendages* of the uterus are supplied with nerves as fol-

lows: (1.) The *ovaries* receive branches from the spermatic plexus alone, so far as is known; though there are doubtless some spinal nerve-fibres in the branches sent to them. The uterus also receives branches from the same plexus, as we have seen; and hence a direct sympathy between the uterus and the ovaries, both in their physiological and in their pathological states. (2.) The *Fallopian tubes* receive branches from the spermatic plexus also, and a branch from one of the uterine nerves. Thus, they sympathize with the ovaries on the one hand, and the uterus on the other. Like the ovaries, they are not known to receive any distinct branches of spinal nerves. The importance of this triple sympathy in relation to the fecundation of the ovum, and its subsequent transmission through the Fallopian tube into the uterus, will not be overlooked. (3.) The *round ligaments* are supplied from the lumbar plexus and the spermatic plexus.

3. The *vagina* is supplied with nerves from the sacral and the pelvic plexus. It has already been stated that even in the sympathetic branches from the latter plexus, the spinal nerve-fibres predominate, and hence its higher degree of sensibility as compared with the uterus. The *vulva* is supplied from both the lumbar and the sacral plexus.

But this must suffice on this topic. My object is to prepare you to expect a variety of pains, and other modifications of sensibility, in cases of disease of the uterus and its appendages; for since, as we have seen, a direct sympathy of the uterus itself with all its appendages exists on the one hand—while, on the other, there is a sympathy between each of these and more distant parts deriving their nervous endowments from the same source—we can never predict precisely what or how many peculiar sensations may be developed in any particular case; and we may perhaps have the same symptoms in cases quite unlike.

And you will now, I trust, more fully appreciate the statement, since you can give a reason for it, that many symptoms may be common to a great variety of uterine affections; that the mere rational signs of uterine displacements are not at all reliable; and that a vaginal examination alone can lead to a *positive* diagnosis.

Prolapse of the uterus will be the subject of my next lecture.

On the Mechanical Means adopted in the Treatment of Morbus Coxarius. By H. G. DAVIS, M.D. *(With a Plate.)*

The results obtained from the present modes of treating morbus coxarius are not so satisfactory as to require an apology when a new method is proposed, especially when that method, in some important particulars, has thus far in its application proved perfectly satisfactory.

It is my intention to confine the contents of this paper almost exclusively to a description of a method of treating this disease which I have pursued for twelve years; and as it has never been brought before the profession, it becomes necessary to describe it minutely. As I proceed in the description of the apparatus used, and the manner of its application, it will be somewhat necessary that I indicate the reasoning which guided me towards its adoption.

The several parts employed in the treatment are four strips of adhesive plaster, (see Plate, Fig. 1;) a roller to confine them to the limb, firm webbing to be attached to the lower end of the adhesive plasters when upon the limb, (Fig. 2;) a cord, pulley, and weight, for extension when upon a bed or couch; a corrugated steel splint, (Fig. 3,) with a perineal band, composed of two parts—an inelastic, (Fig. 4,) and an elastic, (Fig. 5)—arranged in a peculiar manner, so as to keep up extension while the patient may take exercise within the house or in the open air.

When called to treat a case of morbus coxarius, I bring the tibia in a line with the femur, but attempt no change in the direction of the latter if it is not parellel with the body. If the femur is flexed upon the pelvis, the body should be raised until the limb will lie extended upon the mattress or couch. Adhesive straps are placed upon each side of the limb, in the following manner: First, double over one inch of each adhesive strap designed for the sides of the limb, bringing the adhesive surfaces in contact for the purpose of increasing the strength of the part, to which a firm inelastic webbing is to be attached. The strip for the outside of the limb commences with the folded end mentioned, at a point one inch above the external malleolus, and extends to the region of the great trochanter; that upon the inside, from one inch above the internal malleolus to within one inch of the pubis. Upon the lower end of the adhesive strap, on the outside of the limb, I commence with a narrower and longer one, and run it spirally around the limb until it reaches the upper end of the longitudinal straps; another starts from the same point upon the outside of the limb, but winds in the opposite direction. These spiral strips accomplish a two-fold purpose: they connect the outside longitudinal ad-

hesive plaster with that upon the inside of the limb, so that any extension made upon the outside plaster is shared by that upon the inside. This arrangement also secures the bottom of the outside longitudinal plaster from being displaced laterally when the splint is applied, always retaining it in a line with the limb. The width of these plasters varies from an inch and a quarter to two inches and a half, according to the size of the patient.

When the extension is made by the splint, it is always upon the outside of the limb; at other times it can be made from both sides; the latter mode of extension supports the sides of the foot equally, and is therefore preferable when the patient is upon the bed or couch.

Before proceeding further, I would say a word upon the character of the adhesive plaster to be used for such purposes, as that ordinarily used for dressing wounds will only disappoint the surgeon. It should be spread upon twilled goods, as they are more elastic; and when the extension is made the parts first affected will yield until the whole surface of the plaster bears a portion of the draught; whereas plaster upon plain cloth draws only in a straight line, therefore is only applicable to an even surface.

The material of the plaster should not only be good, but it should have been spread upon the cloth for at least one year, and it is still better if two years old; age oxydizes the oil, rendering it resinous, so that the oily secretions from the skin do not readily soften it. Plaster of this description I have had remain upon an adult for seven months, sustaining a weight of twelve pounds every night, and not unfrequently during the day a considerable portion of the entire weight of the body.

After the application of the adhesive straps in the manner described, the limb should be covered with a bandage from the foot to the pelvis, to secure firm adhesion of the plasters, also to prevent their edges from being raised by coming in contact with the clothing, or by the hands of the patient during sleep; this bandage should be affixed to the limb for some hours, with the patient warm in bed, before any draught is made upon the adhesive straps, that they may become firmly adherent to the limb; after this time has elapsed, a weight, varying from two to six pounds, according to the strength of muscle and the sensibility of the joint, may be attached to the adhesive straps upon each side of the limb by a cord that runs over a small pulley secured to the foot of the bed or couch; the top of the pulley being a little above a line with the centre of the limb. This weight should be increased from day to day, until a general sensation of fatigue is felt in the entire limb to an unpleasant extent, and then diminished until it just falls short of this point. The extension is first made at that angle

with the body that I find the limb; as the tenderness of the joint subsides, the body should be gradually lowered until it is brought in a line with the limb; when this is effected, the splint can be applied, and the patient put upon crutches and permitted to exercise.

Upon the lower end of the adhesive straps attached to the outside of the limb, I secure a piece of firm, strong webbing, of sufficient width to support the weight of the patient; this passes over the end of the splint, and is inserted into a buckle on its outside, near the joint.

The counter-extension is now ready for the splint; this I make of steel, of sufficient width and thickness, that when corrugated as it is in the splint, it will sustain the weight of the patient without yielding; and it is surprising how little weight of material it requires to fulfill these indications when put into the corrugated form. A strip one inch and a half wide, of No. 16 rolled cast-steel, when corrugated, will sustain, endwise, the weight of an adult without yielding.

The splint has a joint near the knee, for the purpose of rendering it easy of application. The lower portion overlaps the upper, and when the splint is brought up to the limb, and the extension made, a piece of steel in the form of a band slides over the end of the overlapping portion, and secures the joint. The bottom of the splint, in some cases, I make of a separate piece, with holes for altering the length, and secured by screws to the other; but without this the splint admits of a difference in the length of the limb of two or three inches, which is frequently all the alteration that is necessary. If the webbing attached to the plaster is some wider than the bottom of the splint, it will contract over the corners sufficiently to retain the splint in its fold; to make it still more secure, the lower end of the splint can be cut into, forming slight grooves, into which the threads of the webbing will draw, thus preventing displacement. Just below the joint, in the splint, is the button for the attachment of the buckle, before mentioned. Quite at the top, and inside of the splint, is an eye, through which runs the catgut attached to the two ends of a perineal or extending band, and forms a part of it when the whole is applied to the patient; the catgut, passing through this eye unconfined, allows the upper portion of the splint to traverse back and forth without disturbing the perineal band. All of that portion of the splint that passes above the hip-joint has a motion, of which the joint is the centre. By this arrangement, allowing the catgut to traverse in the eye of the splint, the perineal band is not disturbed by any motions of the limb, and all irritation from motion is avoided. The whole of the splint is covered with leather, with the exception of a small space at

the bottom, and that occupied by the joint and its fastenings; between this and the limb is a flat piece of leather, to prevent irritation from this part. The perineal or extending band is a very simple, though a very important contrivance. It is so arranged that any amount of extension can be made; yet, when the patient steps upon the limb, it yields no further.

There is, first, an elastic band made of rubber, or rubber webbing, to which two buckles are attached, one at each end. In addition, there is a piece of inelastic webbing, that is from eight to twelve inches longer than the elastic band mentioned; this passes through the buckles in such a direction that when draught is made upon each end, the buckles take hold of the webbing and confine it; by this arrangement of the two bands they can be buckled at different lengths; by leaving the outside inelastic band loose between the buckles, any draught applied at the ends of the inelastic will be communicated to the elastic band, extending it until it is of the same length as that portion of the inelastic band contained between the buckles; then the latter will prevent any further extension. By this arrangement it will be perceived how a certain amount of extension can be kept up; yet when any additional labor is thrown upon the splint, as when the patient leans upon the limb, it will yield no further. The loose ends of the inelastic webbing I fold back upon themselves, and introduce into the buckles; where the folds come, a steel ring is stitched on securely, for the purpose of fastening the piece of catgut that is to pass through the eye at the upper end of the splint; the end of the inelastic webbing is folded back, as mentioned, that the length of the perineal band may be varied without untying the catgut. Both ends of the perineal band are secured to the catgut after the latter is placed in the eye at the top of the splint; the whole forming a loop that can be put upon the limb over the foot without disturbing any part. For a cushion beneath the perineal band, I use old table linen, or old napkins that are soft; they should be folded an inch wider than the perineal band, and a little longer; after folding, the parts should be caught with a needle and thread, to prevent their displacement.

These cushions should be changed every second day, particularly during warm weather, as they collect the secretions, and then are liable to excoriate the parts. For the first few days, care should be taken that the splint is not kept on, after anything like a sensation of heat or smarting is experienced in the groin. If proper care be observed at first, the parts beneath the perineal or extension band will have become so hardened as to render any excoriation improbable.

Whenever the splint is removed, the extension by means of the weight should be applied, that the diseased surfaces of the joint may be constantly separated. The splint is intended to fit closely to the outside of the limb, and to be worn inside the stocking; that this may be done, and also that it might be worn unperceived, I have avoided all additions to its thickness. Irregularities upon its surface have been guarded against, as they would soon wear a hole through the clothing, and thus become obnoxious. The eye for the catgut is the most simple form of accomplishing the object, is never liable to get out of order, and in my hands has not originated an objection. If the mechanic who constructs it is not aware of its use, he may leave it so unfinished as to fray the catgut, but this is no fault of the principle. I have an adult patient that has used the same piece of catgut for ten months.

This plan of treatment has been foreshadowed in the various contrivances and operations adopted by surgeons, and with varying success in proportion as they carried out the principle involved, and, as I conceive, fully applied in the mode just described.

It is not an unfrequent occurrence that a failure results from an imperfect application of a correct principle. Hence, we often see the revival of some principle of treatment, followed by success, that has previously been condemned, because of its imperfect application.

I have delayed bringing the subject of this paper before the profession until time had given me an opportunity, not only to overcome any minor difficulties that might arise, but to test its application, and compare the results with the modes heretofore practiced. It is an unfortunate circumstance that so many new things are hurried before the profession in a crude state, to be condemned or die of neglect, when they would have been highly useful if the inventor or discoverer had taken time to digest and mature his plans, and then apply them until all objections or difficulties in their use should be overcome.

The advantages of this plan of treatment are:

1st. It relieves all suffering after the limb is brought down in a line with the axis of the body, and the sensibility of the joint has had time to subside; but from the commencement, there is a decided mitigation. The time requisite to bring the limb down varies from one to twenty days, according to the tenderness of the joint and the contraction of the muscles. I give it as a rule to the attendants, that whenever the patient complains of pain, they may be certain there is not the proper amount of extension upon the limb.

2d. It retains the limb in the best position as to length, &c., whatever may be the result to the head of the bone.

3d. It puts the diseased parts in the best position for their restoration with a perfect joint, as it relieves the pressure upon the head of the bone, while at the same time, it admits of motion, which increases the recuperative energy of the parts, inasmuch as it increases their vitality.

4th. In consequence of the favorable results mentioned, the patient's life will rarely if ever be sacrificed to the disease.

The relief afforded the parents and friends of the patient might be mentioned, as there are few diseases that make a greater demand upon the sympathies and physical efforts of parents and friends than this.

In a former paper, I incidentally mentioned the relief from irritation afforded by separating the head of the bone from the upper portion of the acetabulum. I have had patients with very depraved constitutions, where large abscesses had formed about the joint, in whom hectic fever would have been sure to follow their opening under the old mode; but while extension was kept up, not an unpleasant symptom followed, not even so much as any impairment of the appetite. This favorable result I have seen follow the opening of abscesses both in Pott's and hip disease, when the parts were kept separated.

It will not be expected that every case of morbus coxarius, although treated upon this plan from the commencement of the disease, will recover with a perfect joint; yet we can safely rely upon a far larger per centage than by any other mode; in addition, whatever may be the point at which the disease stops, the limb will be left in the best condition possible, considering the loss of structure sustained. If the head of the femur should be entirely destroyed, the limb should be kept at its full length; and if anchylosis takes place, it does so without material shortening of the limb. If a patient should recover from the disease while wearing the apparatus, great care is requisite that it be not laid aside too soon; the necessity of this caution becomes evident, when we consider upon how small a surface of the head of the bone, or of the cavity of the acetabulum, must rest the whole weight of the body, and frequently many times its weight, as in jumping, &c.

Again, this very small surface is the portion that has just recovered from disease, or, in other words, is a fresh cicatrix, the vitality of which is less than that of the original structure. There is yet another consideration: if inflammation takes place in this part, it will be of a far more active character than that with which it was at first affected, and will very probably speedily result in suppuration if not subdued. The remedial measures should be much more active, particularly the local treatment, than in an ordinary case of hip disease.

It will be observed that the treatment I have presented is entirely mechanical, therefore does not interfere with any constitutional or local medication, which any gentleman may consider advantageous. On this part of the treatment I do not design to speak at the present time, but reserve it for a future paper.

67 UNION PLACE.

A Glance at Medical Science among some of the East Indian Nations. From the French of Dr. L. S. HEYMANN.

The prescriptions of the Javanese doctors, called *dukum* in the Malay tongue, are always very complicated, consisting of ten, twenty, or a larger number of drugs, each one destined to combat one of the most prominent symptoms of the disease under treatment. Among the substances which make up the Materia Medica of the Javanese, there are some possessed of incontestable pharmaceutical virtues. Some of these have been recently tested in the hospitals of Java, and in similar establishments on the other isles of the Sound, and the experiments have been successful.

The Javanese physicians do not trouble themselves about the diet and regimen of their patients; but, on the other hand, they administer drugs as frequently to those who are well, to preserve their health and prevent disease, as with the view of curing it. Chiefs and persons of high station are incessantly occupied with the condition of their health, and consequently take daily different medical compounds. Among others, there is an officinal preparation, called *Djamoe*, which is employed largely by those who desire to protect themselves from all kinds of disease, and which is composed of from fourteen to twenty-six different substances. It is not employed until the age of fourteen years is attained, but other compounds, more or less analogous, are used for children. The child in the cradle is exposed to the necessity of using these, while the most decrepit old men also demand of *djamoe* additional years of life and health. The following articles enter into the composition of Djamoe: Carum carui, Meeso-i, Cinnamomum sintoc, Sprantu, Semen Coriandri, Nux moschata, Anethum graveolens, Alumen, Capsicum bicolor, Piper cubeba, Piper nigrum, Kedawung, Caryophillus aromaticus, Citrus limonellus, Asafœtida, Rad. Glycyrrhizæ, Cort. Cinnamomi, Kajuang-ngien, Kæmpferia rotunda, K. galanga, Allium cepa, Ocymum basilicum, Drymariæ, Klabet, Flores Bixæ Orellanæ, and Djongrahab.

Djamoe cannot be an inert preparation. The different articles are mixed in definite proportions, always represented by odd numbers, to which great cabalistic importance is attached. They are pulverized on a smooth stone, moistened with lemon-juice and holy water; verses of the Koran are recited during the manipulation, and finally boluses are formed, which are administered in the morning. A more simple djamoe contains only eleven of the substances already mentioned, with the addition of Calamus aromaticus, Acorus calamus, and *temulawak*. Aside from its preservative qualities, djamoe is said to be very efficacious in intermittent fever and colic. If the fever does not yield to three or four boluses administered the first day, the lemon-juice, employed in the preparation of djamoe, is replaced by urine. In the treatment of colics, a little brandy is added, especially in frequently-recurring cases, where they are brought on by the use of green fruit.

Djamoe, prepared according to the first formula, is extensively used to produce abortion. This is not considered as an immoral or reprehensible act. Married women often procure abortion with the consent of their husbands, and without any effort to conceal it. It is difficult to say whether djamoe will alone produce abortion, as other means are employed along with it. However, when abortion is required, or the cure of disease, the consummate experience of some matron often renders the intervention of a *dukon* useless. There is no Javanese family which does not possess a supply of the most common medicines, contained in a casket, along with a stone plate and a kind of pestle—the only instruments employed in the preparation of medicaments. Scales and weights are not used—an approximative guess determines the dose.

Among the different mixtures which these domestic pharmacies contain is a panacea, frequently used, made of Kæmpferia galanga, K. rotunda, Curcuma rotund. et long., Allium sativum, and common salt.

These substances are triturated, and boluses are made, as in the case of Djamoe, which are administered at intervals of one or several hours. Frequently it is proposed, in this way, to produce abundant diaphoresis. It, however, produces, at times, colics and diarrhœa, and, if persevered in, dysenteric symptoms, which it would be considered very bad to treat immediately.

Such is the Therapeutics of the Javanese. As they rarely employ a medicament without associating it with a number of others, it is not possible to determine the special action of the different drugs. There are some, however, whose efficacy in certain affections has been de-

monstrated by the most exact experiments. Thus, the root of the Trebah Japan *(Rhinacanthus communis)* seems very efficacious in the treatment of Herpes circinnatus and H. phlyctenoides. A mixture is prepared, by rubbing it with vinegar, which is applied three times a day on the affected portions of the skin. It is ordinarily only necessary to repeat these applications twenty-one times to insure a cure. Among the drugs produced on the island of Java are some that have been long known in our own shops, viz.: cassia, croton, ricinus, &c. Although the Javanese principally seek their remedies in the vegetable kingdom, yet they employ a number of products obtained from the animal and mineral kingdoms—among the latter, copper and arsenic being frequently used.

The excrements of a large number of animals also enjoy great pharmaceutical repute; but the human urine is the most celebrated of all these. When an accouchement progresses slowly, the urine of the husband or of some one else is administered to the woman. This disgusting agent is also popular in the treatment of asthma, and, as a topical agent, it is considered the best of all collyria.

Dysentery has furnished an opportunity to the Javanese doctors to invent interminable formulæ. The treatment is always, and invariably, the same, and comprises a certain number of preparations which are to be successively administered. The compound first employed does not differ from djamoe; at the end of twenty-four hours, if there should be no amelioration of the symptoms, a decoction is made of a large number of substances, among which may be found rice and a large number of aromatic fruits, Cubebs and Capsicum longum. In case the patient is a child from five to ten years old, this decoction is substituted by a powder, which contains *album græcum* of the dog, that has been roasted at a fire and sprinkled with lemon-juice.

It is only when the resources of the domestic pharmacy have been exhausted that the patient is intrusted to the care of some medical notability of either sex. When the Javanese doctor approaches the patient, he fixes a look of attention or inspiration upon him; then pompously draws forth a bag containing the Djimat, (the formula of exorcism,) which is a band of paper covered with Arabic formulæ, and folds it with special care. This bag being placed upon the most painful portion of the patient's abdomen, he prepares the *Dukon*, (reciting, at the same time, a long series of prayers,) and places it under the ear of the patient, with one or more notes covered with hieroglyphs. This being done, he throws a nail, made red hot in the fire, or a magic stone, *(mustika,)* into the consecrated water, which the patent immedi-

ately drinks. For a last resort, when all other manœuvres fail, and the pitiless administration of a certain quantity of urine proves inefficacious, another *dukon* is employed. In some extremely rare cases, the treatment is finally intrusted to a European physician, who arrives almost invariably too late.

Blenorrhagia is somewhat common among the inhabitants of Java, and they have a large number of formulæ to combat it. In old cases, they employ frequently a mixture of cubebs, ginger, Alpinia galanga, coriander, white pepper, and nutmegs.

From the foregoing, it will be seen that the use of medicaments on all occasions is, among the Javanese, pushed to an extreme rarely met with elsewhere; but after an accouchement, the loosest reins are given to this mania. Whether the labor has been fortunate or not, the woman is covered with layers of countless drugs, either to favor the flow of the lochia, or to keep off all varieties of complication. The delivery is but accomplished, when incontinently a tisan is administered to the mother, prepared of wood cinders and tamarind pulp, or the midwife substitutes for this draught decoctions more or less complicated. The abdomen of the patient is covered with a host of ointments, whose composition varies according to the part for which they are specially designed; and this treatment is continued for weeks, although the most vigorous health of the mother would justify their discontinuance. The new-born child is also subjected to interminable manipulations. The skin is covered with a layer, several lines in thickness, of oils, balsams, and juices of plants—hardly any portion of the body escapes these applications.

Thus far we have written of the indigenous doctors. Java possesses, also, a number of Chinese doctors, and Chinese pharmaceutists. The shops of the latter compare favorably with those of the indigenous pharmaceutists, so far as order and neatness are concerned. Many of them are arranged like European pharmacies, and contain analogous preparations—the most of which are prepared of substances obtained from the vegetable kingdom The mineral substances employed by Chinese doctors are very few. They use, however, a number of substances obtained from the animal kingdom, to which marvelous virtues are attributed, and which are selected from the most disgusting products. For example: toad-flesh cures diarrhœa; that of the *Gecko*, tuberculous affections; that of the bat insures long life to him who uses it; while bat's blood and bile are reputed to cure syphilis, and its excrements are employed as an excipient in the preparation of certain pillular masses.

The skeleton of the scorpion, dried and pulverized, possesses diaphoretic virtues, and cures both rheumatism and small-pox. Horse-brain makes the hair grow; the heart of the same animal, dried and pulverized, strengthens the memory; his bones, pulverized, prevent sleeplessness; and the placenta of the mare cures amenorrhœa: but, in order that all these effects should be had, a *white* horse should be employed. Marrow from the bones of the ass, introduced, during sleep, into the ear, cures deafness; the horn of the rhinoceros arrests somnambulism, if placed under the ear while the somnambulist is asleep; pulverized and cooked in wine with the livers of the goose and duck, the same horn will cure hæmatemesis. Tapir-skin is used as a cushion and for mattresses by those who have vicious humors; and its urine is an antidote for copper poisoning.

In addition to the medicaments of known composition, the Chinese doctors of Batavia employ a large number of secret remedies brought from China, prepared with much elegance, and accompanied with attractive advertisements. These are employed to cure divers diseases, or to give convalescents that *embonpoint* which the Chinese value so highly; some have great reputation as aphrodisiacs, and are often employed to prevent impotence.

Most of the Chinese doctors in Java are not of pure extraction, and have never visited China, and hence they are less educated than their *confrères* of the Celestial Empire. But few escape the influence of the Javanese modes of practice. Equally superstitious, they play the part both of sorcerer and physician, and employ the agency of the stars or of a demon in their practice.

This is all very different in Japan. Medicine has there been cultivated with as much zeal as intelligence, and has attained a remarkable development. The old medical school, proceeding from the same stock as the Chinese school, and partaking of most of its doctrines, has not been slow in modifying these by contact, although limited in character, with Europeans, especially Hollanders and Portuguese. In spite of systematic governmental opposition to all innovation, many of the physicians appropriate freely the medical knowledge and doctrines of the foreigners with whom they come in contact; the study of the European languages opens up to them our scientific works, which they seize hold of with the sole desire of gaining information, which is one of the characteristic traits of the nation.

When the new school, during the second half of the sixteenth century, contended advantageously against the old traditions and European Pharmacology, it would have succeeded entirely, had it not been

for the changes which followed the invasion of the Portuguese. The movement suffered thus a period of arrest, which still exists. Nevertheless, the government suffered the importation of a certain number of medicaments brought from Europe, which were obtained almost entirely from the vegetable kingdom. The number of these substances is very carefully limited, and every argument to increase them encounters insurmountable obstacles from the government. In exceptional cases, authority has been granted to import a medicine whose importation has not ordinarily been allowed, when the demand was made by a physician of renown.

China furnishes Japan a much larger number of medicines than Europe; from her all the rhubarb and opium are procured. There are, however, substances of analogous virtues to many of these medicines among the products of Japan. It possesses no vegetable that can take the place of the cinchonas; and quinine is hence allowed to be imported.

Among the inorganic substances, the Japanese doctors prepare some in accordance with the directions of European pharmacopœias: calomel, corrosive sublimate, sulphate and carbonate of magnesia, tartar-emetic, and the different salts of soda and potassa.

Most of the medicines used in Japan belong to the vegetable kingdom, and many of these are used for the same therapeutic indications as in Europe. Benzoin is employed as an expectorant and antispasmodic, opium and nux vomica as narcotics, catechu as an astringent, gamboge as a drastic, asafœtida as an antispasmodic and anthelmintic, myrrh as an excitant, stomachic, resolvent, and antiseptic; mastic is used in hæmoptysis, asthma, diarrhœa, and dysentery; sanguis draconis in hæmorrhages, dysentery, and chronic diarrhœa.

The mineral substances most frequently employed are as follows: Cinnabar, employed especially in syphilis. It is given in dose from 50 to 75 centigrammes, in cigarettes. Three or four such cigarettes are smoked daily, in order to bring on profuse salivation. Mercury rubbed up with syrup, so as to destroy the globules, is also extensively employed, in the form of pills, in small-pox; and also a mixture of mercury and alum, known as *kei-hun*. Tin filings, mixed with syrup, are used as an anthelmintic; and sulphate of iron, dissolved in water, as a hæmostatic.

A number of substances obtained from the animal kingdom are also to be found in the Japanese Medical Arsenal. Musk serves to combat spasms. Certain serpents, carbonized on a slow fire and then pulverized, are used in the treatment of syphilis, lepra, and chronic

exanthems; an analogous preparation, made with *Gecko*, is employed in affections of the kidneys and bladder. Decoction of toads, frogs, and salamanders is reputed to cure convulsions, epilepsy, intestinal worms, chronic catarrhs, croup, tubercles, dropsy, and constipation; powders are likewise prepared from these animals, which are applied on tumors, ulcers, and different cutaneous lesions. The fat of the toad, called *Fiki-Kaheruabura*, is reputed to be very effective in preventing accidents during dentition.

The *cantharis* of Japan is smaller than the species used in Europe, but more active. This is used in vesecation, and is administered, in form of powder or infusion, in divers chronic affections of the genito-urinary organs. The Japan leeches are also very small, but they are rarely used.

The indigenous medical drugs are divided, by the doctors of the new school, into five classes, in accordance with their therapeutic action, viz.: acrid, tonic, and astringent; excitant and roborant; nervine and narcotic; resolvent and nutrient. These are distinguished by the Japanese or Chinese names, although most of the physicians are familiar with the names employed in European Pharmacopœias. They administer the medicines as decoctions, infusions, powders, and pills; and tinctures, electuaries, and extracts are also employed. There are no regular Pharmacies in Japan. Drugs are sold in their natural condition, either wholesale or retail, in the shops, where any one, whether professional or layman, can purchase. The physicians prepare and dispose of the various preparations which they prescribe. —*Gazette Hebdomadaire.* L. H. S.

Dragées of Iron, Manna, and Bismuth. By DR. MORIN.

The objections to ferruginous preparations may be thus summed up: if they are insoluble, they are frequently useless; if soluble, repugnant to the taste, and fatiguing to the stomach and intestines. The new preparation suggested by Foucher, a pharmacien of Orleans, combines all the advantages claimed for preparations of iron, while it presents none of the inconveniences for which they have so justly been reproached. The formula is as follows:

R.—Ferri pyrophosphat.,	0 05 gramme.
Bismuthi subnitrat,	0 05 "
Mannæ puriss.,	0.25 "

This is sufficient for one dragée. These medicinal agents, being

thoroughly mixed, will form dragées easily chewed. They are called *manna-bismuthic dragées of iron.*

The iron salt, the pyrophosphate, is a fixed salt, constant in its composition, perfectly soluble, without injurious action on the stomach, not decomposable by the acid products of that viscus, and most easily absorbed and assimilated. So much for the true active principle of these dragées. But it is useless to dwell upon *this*, since academic reports, as well as clinical experience, demonstrate the advantages of this salt. As for the subnitrate of bismuth, practice has, to a certain extent, indicated that its addition to iron is indicated logically. Hence, for a long time, a prominent physician of Paris, well known for his protracted investigations on the physiology and pathology of the digestive organs, Dr. Gaubert, has used the subnitrate of bismuth in all young, lymphatic subjects, possessed of great nervous susceptibility of the intestines, whose health demanded the employment of tonics. Subnitrate of bismuth is the hackneyed remedy, so to speak, for all gastralgic pains. Its addition is so physiological, so rational, that it might be asked how it happened that its application, as made by Foucher, had not been made by every one before.

The manna has a double effect: it combats the constipation which the ferruginous preparations excite, and at the same time maintains the pyrophosphate in a permanent state of solution—thus allowing of its absorption throughout the whole extent of the digestive apparatus.

A word must be said as to the form of this preparation. It is almost a case where one might employ Cuvier's expression, "The form is more essential than the substance!" To say *more* essential would be going too far; we shall content ourselves by saying that a medicament in the form of a dragée—a true *bonbon*—particularly pleasant for children, is something not to be despised in numerous diseases, where martial preparations are needed.

To conclude, if we may be allowed to institute a comparison between Foucher's preparation and the other ferruginous preparations, we would say that his dragées are agreeable to the taste, whilst most of the others are disagreeable. His is inoffensive to the stomach, whilst most of the others fatigue and irritate that organ; his does not produce constipation, the others provoke a tedious obstruction of the digestive organs; his remains soluble in the midst of the digestive mucosities, and is promptly and completely assimilated; the others pass through the bowels without being assimilated.—*Gazette des Hôpitaux.*

L. H. S.

Action of Chloride of Zinc as a Caustic. By SALMON and MAUNOURY, Surgeons to Hôtel Dieu, at Chartres.

The experiments on which the conclusions here given are based, were made in connection with those already furnished our readers, in the last number of the MONTHLY, p. 188, on the action of caustic potassa. They comprise a series of carefully executed experiments as to the action of chloride of zinc on living and dead tissues.

Chloride of zinc, as compared with caustic potassa, is an agent producing cauterization very slowly. It does not dissolve tissues, but on the other hand, renders them harder and more coriaceous; under the microscope, one can recognize very readily all the anatomical elements of which they are composed. The cauterized surface prevents the ready penetration of the fresh caustic, when it is desired to act at a greater depth; and then it is necessary to remove the eschar, already produced, by caustic potassa, or to cut off the same by the bistoury, or to await its removal, which requires from six to eight days.

It is a caustic which does not spread under the following conditions: 1st. When it is applied on moist or fungous tissues, on a wound, &c. 2d. When the successive layers of the tissue to which it is applied are all of like ready penetrability. But if, under a tissue easily destroyed by the cauterization, an aponeurotic expansion, muscular tissue, &c., be found, it scarcely penetrates these, and spreads through the tissue on which it has been applied, until it doubles, or even triples, the size of the required eschar; hence it cannot, with justice, be said that chloride of zinc destroys tissues like a punch.

It destroys cellular tissue more readily than cutaneous; and the latter more readily than fibrous or muscular tissue, &c. Contrary to the assertion of Gironard, it attacks morbid tissues, such as cancerous growths, with the same facility that it penetrates fungous tissues. If the morbid mass be enveloped with a fibrous covering, the zinc caustic can isolate this mass, but this does not imply the rapidity of its penetration in the morbid tissue when deprived of its envelope. It coagulates the blood even in large vessels, but does not prevent hæmorrhages from following its employment, even when the arteries are only of medium size. Eschars formed by it are soluble in potassa, and this property can frequently be utilized with the view of hastening the termination of cauterizations.—*Gazette Médicale de Paris.*

L. H. S.

Spontaneous Cure of Cancer of the Breast.

Guerdan, of Billigheim, having a female under treatment for cancer of the left breast, with swelling of the axillary glands, sent her to Professor Chelius, who pronounced the case not suited for operation. It was decided then to employ the hemlock plaster. The physician was sent for, one evening, in great haste, and finding the patient bathed, as it were, in a pool of arterial blood, he ordered, without any great hopes as to the result, five drops of tinc. ferri. muriat. æther. every half hour. On his seeing her again, she told him that, after her return from the hospital, erysipelas had appeared on the diseased breast, which surrounded the tumor with a dark-red circle, for which she had employed fomentations of cold water. After some days, the circle changed its color from a bluish-red to a leaden hue; the scirrhous breast was covered with sanies; by degrees the whole diseased mass was decomposed into a granulated mass, analogous to a mixture of sanies and gluten, and, in five months, the whole cancerous breast was removed, leaving the pectoralis major exposed. Not only did granulations form a normal cicatrization, but the axillary glands, whose volume had diminished one-half during the suppuration, continued to disappear, until it was difficult to detect them by the touch. There remained nothing abnormal on the cicatrix, except a horny crust, which was kept covered with charpie and flannel. From that time, this person enjoyed good health, presenting no trace of cancerous disease or diathesis, and died eight years after, of an acute pleurisy.—*Echo Medical Suisse.* L. H. S.

Topical Application for Tumors of the Breast.

There are some benign tumors of the breast, resembling cancer, which are frequently extirpated. Dr. Chabrely has published some observations on certain forms of these tumors, that can be cured without an operation, although months of treatment are required, and frequent applications of the following powder:

R.—Amyli,	grammes 2.50	
Pulv. Iodini,	gramme 0.50	to gramme 1.
Morphiæ muriatis,	" 0.40	

This powder is spread on some wadding, and then kept in contact with the diseased part by means of a suspensory bag.—*Bulletin Gén. de Thérapeutique.* S.

Alum Pastilles.

A Venetian physician, Dr. Argenti, proposes the use of alum pastilles, in place of alum solutions, prescribed as gargles in laryngo-pharyngeal anginas, in aphony and dysphony of singers, as well as for aphthous ulcerations of the mouth, whether these are simple, scorbutic, scrofulous, mercurial or typhoid. The formula is as follows:

℞.—Aluminis,
Gum Arab.,
Sacchari,
Water distilled several times with cherry laurel, ää, q. s.

To make pastilles weighing 40 centigrammes, (6 grains,) containing from 2 to 3 centigrammes of alum.

The mass, being well manipulated, and extended on a sheet of paper, cut up into pastilles and dried at a low heat, furnishes a preparation in which the astringent taste of the alum is mitigated by the other agents, and which can be preserved for some months. The pastilles are allowed simply to dissolve in the mouth, when the saliva bears the medicinal agent to the affected parts.—*Bulletin Gén. de Thérapeutique.*

S.

Glucosuria in Paludal Fever.

Burdel, of Vierzon, has addressed a paper on this subject to the French Academy of Sciences. The results of his researches are thus stated:

1. In paludal fevers there exists a true diabetes or glucosuria.

2. This glucosuria is only ephemeral; that is to say, being the indication of derangements in the organism, it appears with the fever, persists during its continuance, and disappears with it.

3. Glucosuria in paludal fever shows clearly the existence of a special agency destroying the equilibrium existing between the cerebro-spinal and sympathetic systems.

4. This explanation of Claude Bernard is confirmed by the following facts: The more violent the access, the more intense the chill, the larger, also, is the quantity of sugar in the urine—on the contrary, when the attacks have been frequent and have lost their force, and, in a word, the more a cachexy is established, the less sugar is produced. —*Gazette des Hôpitaux.*

L. H. S.

MONTHLY SUMMARY OF MEDICAL JOURNALISM.

By O. C. Gibbs, M.D., Frewsburg, N. Y.

Bloodletting in Inflammation, &c.—In the *American Journal of Medical Sciences*, for January, Prof. L. M. Lawson has an able article upon the *treatment of inflammation*, with special reference *to pneumonia*, in which the views of Dr. Bennett, of Edinburgh, are strongly combated. Dr. Lawson considers the views of Dr. Bennett, in regard to inflammation and its appropriate treatment, inconsistent with clinical experience and well-established pathological principles. We feel a personal interest in this matter, because we stand committed against the use of bloodletting in pneumonia, and our opinions may have been too imperfectly expressed. We have a high appreciation of bloodletting, as a remedy in inflammation, under certain circumstances. We believe, however, that it has been too indiscriminately employed. It is not every inflammation that is best treated by bloodletting, and this is the point for which we have more especially contended. For the last three years, we have not bled in cases of inflammation of any character, and have seen no occasion to regret it. We have not prescribed bleeding because we object to it as a remedy, but because we have not seen the conditions which constitute a demand for it. In that time, we have, perhaps, treated sixty cases of pneumonia, of all ages, without a single fatal issue. We have sometimes given antimony, always Dover's powder, also quinine sooner or later, and generally the veratrum viride. We are of the opinion that, in this locality, we have been, for several years, under a typhoid influence that modifies all diseases. Should we see a high grade of inflammatory fever as was not uncommon ten years ago, we should probably bleed as freely as ever. Many physicians have supposed that all inflammation, especially of the lungs, should be treated with loss of blood, antimony, and perhaps mercury; and that, whatever the age of the patient, or grade of action, quinine was never appropriate in the early stages of the inflammation. It was to combat this error that we have reported cases of pneumonia treated with quinine, opium and ipecacuanha, successfully, with an average duration of less than ten days.

Dr. Lawson considers the statistics of Dr. Bennett altogether unreliable. We have but little confidence in statistical evidence of any plan of treatment.

We do not understand Dr. Lawson as advocating bloodletting in all cases of inflammation, but in opposing the views of Bennett and others, that it is never beneficial, but always prejudicial.

In this view we heartily concur, and the following quotation from Dr. Lawson's paper cannot be too attentively considered: "It is evident, therefore, that a rational treatment must secure to each case its own individuality; and as the shades of differences and the corresponding modifications of treatment cannot be expressed in *groups*, statistics, in this sense, become simply an impossibility. For example, bleeding, antimony, mercury, and blisters may be demanded in one case; quinine, opium, and wine in the next; a third may require but little interference except a well-regulated diet with moderate stimulants; and so on, *ad infinitum*. The treatment of pneumonia demands not a single, but many agents; and he who would attempt to develop results by statistics, will be required to make each group a *unit*. It is the proper *combination* of remedies, and not a single agent or mode of practice, which is capable of securing the best results in the treatment of disease."

While Prof. Lawson admits that there is a lowering of the grade of diseased action of late, which requires less depletion than formerly, yet he is "inclined to believe that the great outcry against bleeding has driven us to the opposite extreme, and we now deplete less than the interests of our patients frequently require." This may be true in some localities; but, as we have observed, physicians have been slow to recognize the lowering grade of diseased action, and have bled beyond the requirements, or, as we believe, the necessities of the present modified forms of disease.

In the *New Orleans Medical and Surgical Journal*, for January, is a paper on *Inflammation*, by Prof. Warren Stone, of New Orleans, that might be profitably read in connection with the paper of Prof. Lawson. We have not space here for an analysis of it, but will take the liberty to quote a pertinent passage or two. Prof. Stone recognizes the propriety of opposite modes of treating inflammation, rendered appropriate, and even necessary, by the circumstances of individual cases. Thus, he says: "In an inflammation, when we can afford to pull down, no great skill is required in the management; but when we are required to build up and lend force to vital actions, much delicacy is required in the management." Further, and more to the point, in regard to the subject of Prof. Lawson's paper, he says: "There is no disease, I believe, in which a fixed routine treatment operates so badly as in pneumonia; and those who have continued the old plan of bleeding, when thought admissible, and giving tart. antimony in the first stage, and calomel in the second stage, have been the most dangerous routinists."

With the above remarks and quotations, we leave two very important contributions to the medical journal literature for January.

Nitric Acid in Remittent Fever of Adynamic Type.—In the *American Journal of Medical Sciences*, for January, Dr. Bedford Brown, of North Carolina, has an article upon the adynamic type of remittent fever and its treatment. We quote the substance of his views in regard to treatment. He says: "While a large majority of patients, suffering from attacks of the simple and inflammatory forms of the disease, will recover under the use of such means as local and general bleeding, moderate purgation, sulph. quinia, mercury, oil of turpentine, &c., these remedies have proved utterly inefficient in the adynamic or malignant types." Speaking of nitric acid in such cases, he says: "The tonic properties of the acid are not due simply to any influence which it may exert on the digestive organs. But that it aids in the formation of the blood, and renders it more plastic and organizable, cannot be doubted." * * * "With these considerations in view, I resorted to the use of this remedy in the treatment of remittent fevers of an adynamic type. The powers of the remedy have been satisfactorily tested in at least forty cases by myself and partner, Dr. Roan. The acid was administered in simple cases, in connection with sulphate of quinia and other minor remedies. To the quinia it has certainly added efficacy. A large proportion of the cases were of a decidedly malignant type. In a sufficient number of these to determine its value the acid was administered alone, with the exception of a few remedies of minor importance. I do not remember a single fatal case after its free and constant use. I am also impressed with the belief that it possesses much power to prevent the development of adynamia when given early. Patients, after the use of it, recovered more rapidly and completely than under the usual treatment. Under the influence of the acid it was pleasing to witness the change of form to a more simple character, by a successive clearing up and subsidence of the alarming symptoms."

Vesico-Vaginal Fistula.—In the above-mentioned journal for January, W. L. Atlee, M.D., reports a successful case of operation for this troublesome affection, accompanied with remarks in regard to the method of operation. Dr. Atlee's plan is a modification of that of Dr. Sims and of Dr. Bozeman, which modifications he considers improvements. While he ascribes great praise to Dr. Sims for the introduction of the silver suture, he yet believes the blue iron-wire is the best, possessing "in a high degree every property belonging to silver, while in other respects it is preferable." He uses the but-

ton of Dr. Bozeman, with some modifications. The button "has a fenestrum along its centre, proportioned to the size of the fistula." He brings the edges of the wound firmly together before applying the button or plate. With the instrument invented by Dr. Cogbill, he secures the coaptation of the raw edges of the fistula, with the greatest certainty, by twisting every alternate suture. Having brought the opposite sides of the fistula into perfect contact, by twisting the alternate sutures, these sutures are brought through the fenestrum, while the remaining ones are carried through holes in the button, tightened and fastened with shot, precisely as in the method of Dr. Bozeman. Another improvement, more of convenience than otherwise, is practiced by Dr. Atlee. Each suture, as it is introduced, is fastened to a transverse thread, which arrangement prevents tangling of the wires, and corresponding ends of sutures are found without exposing the fistula. The figures accompanying Dr. Atlee's article make his plan of operation perfectly comprehensible.

In the *New Orleans Medical and Surgical Journal* for January, Dr. Bozeman has an article upon *urethro-vesico and recto-vaginal fistulas*, in which he holds to different opinions, in regard to metallic sutures, from Dr. Atlee. It may be observed here that Prof. Simpson, of Edinburgh, agrees with Dr. Atlee in his preference for the iron-wire over that of silver. Dr. Bozeman thinks the silver is incomparably superior to the iron-wire for ligature in these operations. He says, "I have never yet seen iron-wire remain in the tissues, even a few days, without being turned black. Not only this: I have always observed, where there was much dragging upon the sutures of this metal, they would cause ulceration, and frequently cut out."

In the *London Lancet* for February, (American reprint,) Dr. Isaac Baker Brown has an article upon the above subject. He has now operated 27 times with but one failure, a success perhaps greater than any other operator. Dr. Brown seems rather indifferent whether the silver or iron wire is used. He thinks, however, he has made great improvement over Bozeman's button, in the use of bar clamps. These clamps he thinks possess many advantages, among which the most important are that the edges of the wound may, with *certainty*, be held "in perfect apposition all along the fistula," and "that, however irregular the opening, you can follow its tortuosity without the slightest difficulty." In the *Nashville Journal of Medicine and Surgery* for February, Prof. Paul F. Eve has an article upon the above subject, in which he proposes a *screw-clamp* and the *twisted suture*. For

his method he claims many advantages, but which we have not space at present to particularize.

Hydrophobia.—In the January number of the *American Journal of Medical Sciences*, Dr. J. E. H. Ligget, of Middleburg, Md., reports a case of hydrophobia, successfully treated with drachm doses of calomel. The patient was first bled to the amount of 36 ounces, and then drachm doses of calomel were ordered "to be repeated every *four* hours, if the symptoms remain unabated. If the spasms decline in frequency and violence, the intervals to be lengthened to six or eight hours." Ptyalism was well established on the third day. Opium was given occasionally, and quinine to counteract the tendency to exhaustion. The patient was discharged cured on the 11th day of treatment. Dr. Ligget says, "The increased flow of saliva appears to be a conservative effort of the *vis medicatrix* to eliminate the poison from the system, through the glands engaged in its secretion." This opinion forms the basis of his treatment. The theory of its action is of but little importance, if the utility of the treatment be established by subsequent experience.

Diphtheria.—In the *New Orleans Medical and Surgical Journal* for January, Dr. S. L. Bigelow has an article upon the above subject. Diphtheria has been a fruitful theme in journal literature for some time past. We have endeavored to keep our readers thoroughly informed in the more important opinions in regard to treatment. Dr. Bigelow thinks "diphtheria rarely occurs as a sporadic disease, almost invariably as an epidemic," and he is strong in the belief that "if there exists a mediately *contagious* disease on earth," it is the disease under consideration. Of its nature he says, "It is evidently a typhoid disease, and as such must be treated from the start; it is a septic disease, and as such must be combated at the earliest moment; it is accompanied by local accidents, and they must be treated as they present themselves."

It would require much space to give Dr. Bigelow's treatment in all its minuteness; as we consider it quite important, we shall, as briefly as possible, give it in substance. He says, "First, then, I advise at my first visit an insufflation of about a drachm of very dry powdered burnt alum, whether I find a commencement of the plastic deposit on the tonsils, or in the pharynx, or not." * * * "At the same visit I also advise a tepid bath of an hour's duration at least," * * * "and a purge of citrate of magnesia." * * *. "I prefer the alum as a topic most decidedly to nitrate of silver, as it forms no eschar to blind you at your next visit, with regard to the exact state

of things in the throat, and also because I have found it really more potent in its good influence as a local application. The tongue is to be held down with a large spoon, and the alum blown in through a single glass tube, six or eight inches long, and one-fourth of an inch in diameter, at the moment when the presence of the spoon in the fauces causes the involuntary act of gagging on the part of the patient. This insufflation I order to be continued every hour until my return." His first general treatment "consists in the administration, every three hours, of ten grains of the chlorate of potash, and ten grains of the bichlorate dissolved in some convenient vehicle, with the administration ordinarily of one-tenth of a grain of calomel in sugar, dry, upon the tongue, every hour or every two hours, stopping and recommencing its administration according to circumstances, which can only be explained or appreciated by the physician at the bedside." * * "In addition to the above, I commence immediately with the use of tonics, stimulants, and the most nourishing possible fluid animal food. Quinine every three hours, in as large doses as can be borne, without producing severe cerebral perturbation; bitters composed of cinchona, gentian, columbo, chamomile, quassia, bitter orange-peel, &c., formed into a strong infusion, to which I add brandy, and a little syrup." This constitutes Dr. Bigelow's treatment, divested of its minutiæ of detail. We said last month that we should expect benefit from an occasional emetic; Dr. Bigelow prefers to remove the pseudo-membranous deposit with long forceps, or by scraping, &c., instead of by emetics, of which he says, "I have never yet prescribed a single grain of emetic in a case of *angine couenneuse*, and I hope that it may never be given me so to do." Of bleeding he says, "I would as soon put my lancet into the vein of a moribund typhique, as to take an ounce of blood from a patient with membranous sore throat under any circumstances of the disease which I have ever witnessed, or can imagine."

In the *British and Foreign Medico-Chirurgical Review* for January, Dr. J. B. Sanderson has an able article upon the pathology of the disease under consideration. We have not space at command to give it an analysis. The article is illustrated with the microscopic appearance of the pseudo-membranous exudation.

In the *Chicago Medical Journal*, for October, November, January, and February, Dr. W. G. Dyas has an able series of articles upon the subject of diphtheria. Dr. Dyas' views of the pathology of this disease do not differ materially from those of Dr. Barker, of New York, whose opinions were given last month. He says: "In croup, there is increased fibrin in the blood, not a putrid crasis, nor a tendency to it,

as in diphtheria: in the one, there is the sthenic type of fever; in the other, a typhoid, or even no fever whatever; the former is not preceded by a depressed, nor followed by a cachectic state; these conditions more or less usher in or supervene on the symptoms of the latter." In the *Journal*, for February, Dr. Dyas enters rather fully into the subject of treatment. He does not favor the administration of calomel, in any case of this disease, except as a cathartic. In regard to emetics, his opinion corresponds with that expressed by us a month ago, but does not accord with that expressed by Dr. Bigelow, as quoted above. He says: "Emetics are occasionally serviceable, especially in young children, at the period of the invasion of the disease, and when the false membrane extends to the trachea. They should never be omitted when, together with fever, there are foul tongue, want of appetite, and nausea early in the complaint." * * * "Independently of their removing morbid secretions, emetics seem to effect some change in the nervous system that controls and directs the physiological transformations of the blood; and when these transformations are abnormal, the deviation from the healthy state may be corrected or modified by some impression resulting from such change." Dr. Dyas thinks that it is upon stimulants and tonics that we have mainly to depend, in the treatment of the disease under consideration. He says: "The best tonic, perhaps, that can be used in this complaint, is the bitter wine of iron, as prepared by Mr. Thompson." The following is a summary of his treatment: "Early in the attack, the administration of an emetic—then a gentle purgative of some mild preparation of mercury and rhubarb, and the application of a 30-grain solution of nitrate of silver to the fauces. Immediately after the bowels shall have been moved, tincture of sesquichloride of iron should be commenced with, alternating the doses with port wine and beef-tea, and at the same time the throat may be enveloped in flannel, steeped in some stimulating embrocation. Some prefer a large poultice of chamomile flowers, whilst others object to all moist applications of this kind. Under no circumstances whatever should leeches or blisters be applied, as they not only tend to a still further depression of the system, but are apt to be followed by cutaneous diphtheria."

Tobacco in Rattlesnake Bites.—In the *New Orleans Medical and Surgical Journal*, for January, Dr. Peake, of Mississippi, has an article upon the antidotal properties of tobacco over the poison of the rattlesnake. He says the efficacy of this remedy is well understood by planters in Arkansas. His own experience is thus given: "While engaged as a land surveyor, one of my chain-bearers was bitten on the

dorsum of the foot by a rattlesnake of the largest kind. It was in the month of August, when the poison of this snake is supposed to be more deadly than at any other time. In less than five minutes I had him chew and swallow near two ounces of common chewing tobacco. It did not cause him to vomit; indeed, so far was this from being the case, that he was not even nauseated by it. His limb swelled but very little, and he was up and about the next day, well."

Under such circumstances, and where Bibron's antidote is not to be had, it would be proper to give the tobacco a further trial. We should, however, about as soon expect recovery to follow the bite, as the administration of *two ounces* of tobacco.

Endermic Medication.—Of late, *hypodermic* medication has attracted considerable attention; but perhaps no more than it deserves. It is, however, quite possible that the merits of *endermic* medication may be neglected in the furor for the new and more difficult hypodermic plan. In the January number of the *New Orleans Medical and Surgical Journal*, its very able and industrious editor, Dr. Bennet Dowler, has a lengthy article *On the Modes of Medication*. We have not space for its analysis, though the article is one of much merit. We will, however, not pass the article without referring to one case therein illustratively alluded to. In a case of *delirium tremens*, in which morphine to the amount of three or four grains daily, and subsequently laudanum in tea-spoonful doses, had been administered for several successive days, Dr. Dowler used laudanum externally, with the effect of speedily putting his patient to sleep. For seven days the patient had not slept, notwithstanding these large doses of morphine and laudanum. Dr. Dowler says: "Next morning a drachm of laudanum was rubbed on the epigastrium, and the same quantity three hours afterwards. Unexpectedly, soon after the last application, he fell into a good sleep. In two days after, he left his bed."

We are confident the endermic method of administering remedies is too much neglected, especially in some cases of gastric irritability.

Stomatitis Materna.—In the *Southern Medical and Surgical Journal*, for January, Dr. D. S. Brandon has an article upon the pathology and treatment of the above-mentioned disease. He is of the opinion that the oil of turpentine will be found to be the most efficient of all known remedies. He says: "I have used it, and caused it to be used, in quite a number of cases since the first of last year, when I began its use, and in no instance that I know, or have heard of, has it failed. If the bowels are costive, I premise a dose of caster oil; then give the turpentine, say twelve drops three or four times a day on a little loaf-

sugar. If there be diarrhœa present, I use equal parts of laudanum with the turpentine, as above." * * "The cure is usually effected in from five to eight days; very bad cases may require more time." However decided may be the benefit to the mucous surfaces, resulting from the use of the turpentine in this disease, we should hardly expect to remedy the constitutional impairment, which always accompanies these cases, without the aid of more decided tonics.

Strychnia in Seminal Emissions.—In a former number of our *Summary*, we made the following remark: "We are confident that the remedial powers of strychnia are not yet fully brought out." This forms the text of an article, by J. McF. Gaston, M.D., of Columbia, S. C., published in the *Southern Medical and Surgical Journal*, for January. From that article we extract the following: "In that deplorable condition attended with involuntary seminal emissions, I have tested it fully and satisfactorily during a series of years, and it really has served my wishes so completely in these cases that I now use no other course of treatment. With a view to secure the best effects from it, a proper regimen should accompany its use; and with such a course, it may almost be regarded as a specific in spermatorrhœa."

Wound of the Brain.—In the *New Orleans Medical News and Hospital Gazette*, for February, Dr. G. Devron reports an interesting case of punctured wound of the brain. The wound was made with a pocket knife, "at a point nearly corresponding to the junction of the sagittal and lambdoidal sutures." The blade was driven completely through the skull and broken off. The patient rested well the first night, and took his meals through the day without complaining. No symptoms of any urgency presented themselves for the first forty-six hours; he then complained of pain in the head, gradually lapsed into a state of coma, and died. On examination, the blade was found "penetrating the brain to the depth of two inches." This case is interesting because of the comfortable condition of the patient for nearly two days after so grave an injury, and because of the sudden death after the first manifestation of pain, or other unpleasant symptoms.

Tongue Removed by the Ecraseur.—In the *New Orleans Medical News and Hospital Gazette* for February, Dr. S. Choppin reports a case of removal of the tongue, for cancer, with the écraseur. The operation lasted fifteen minutes, and was accompanied with no hæmorrhage. This operation is usually accompanied with considerable hæmorrhage, and it is highly probable that the écraseur is, in such cases, a valuable surgical appliance.

Radical Cure of Hernia.—Dr. Choppin, referred to, is an earnest

advocate of the Wurtzer plan of operating for the radical cure of hernia. He has operated many times with success, and has demonstrated, by post-mortem examinations of subjects operated upon years before, that positive occlusion of the canal had taken place; thereby rendering the recurrence of the hernia impossible. The editors of the *Medical News and Hospital Gazette*, referring to Dr. Choppin's operations, and his lecture upon this subject in the Charity Hospital, say, "We have several times before called attention to this most valuable operation, and offer no apology for repeating our opinion, that it is one of the most important surgical innovations of the age, if not absolutely the most important." Several eminent surgeons have ridiculed this operation; but, really, we hope the views and experiences of Prof. Choppin may be proved to be correct by subsequent clininal observation.

Radical Cure of Hernia.—In the *Medical Press*, for February 11th, Dr. J. W. Rosebrugh reports a case of hernia apparently cured, after two operations after the plan of Wurtzer. He says: "The inguinal canal was so large that *three* good-sized fingers could be introduced into it." Hopes of success were entertained after the first operation, but after a month the patient felt something give way, and a fold of intestine descended into the scrotum. On reducing the hernia again, "the canal was found to be so small that the point of one finger could scarcely be insinuated into it." Encouraged by a partial success, the operation was repeated, and three months after there is every prospect of a radical cure.

Prof. J. C. Nott, of Alabama, writing from London to the *New Orleans Medical and Surgical Journal*, and speaking of this operation, says: "In Paris, I talked with Velpeau, the Nestor of French surgeons, with Nelaton, and others, and they all say that Wurtzer's operation, or any other on similar principles, cannot be relied on, the disease returning in the great majority of instances. In fact, the operation is scarcely performed at all now in Paris." Opposed to these views, we may instance the following, as the most recent, in addition to those previously referred to. One of the editors of the *New Orleans Medical News and Hospital Gazette*, in the February issue, says: "The fact that the radical cure of hernia can be nearly always accomplished by the method under consideration is no longer to be disputed, and he who sneers at it is only furnishing a stick with which to have his own head broken."

In the *Charleston Medical Journal and Review* for January, Dr. T. L. Ogier reports twelve successful operations by Wurtzer's method, and he says he has performed nineteen other successful operations, not included in his report. Dr. Ogier concludes his report thus: "Recent cases, in subjects under forty years of age, are always successful, and as far as my limited experience goes, quite free from danger."

In the paper of Dr. Rosenbrugh in the *Medical Press*, the author says he was not aware that the operation of Wurtzer had ever been repeated in the same individual. In the *Medical Times and Gazette* for August 6th, 1859, Dr. Redfern Davies reports forty cases of this operation, in *five* of which the operation had to be *repeated*. He says, "Where the rings are very large, and relaxed, the operation is sometimes unsuccessful, and has to be repeated." Out of Dr. Davies' 40 cases, "but two were complete failures, and of these one was owing to supervention of small-pox."

If the operation for the radical cure of hernia is seldom resorted to in Paris, as we are led to believe by reports, it is frequently and successfully performed both in England and America.

Induction of Premature Labor.—In the *Louisville Medical Journal* for February, Prof. Henry Miller has an article upon the induction of premature labor and abortion, with cases. We refer to it for the purpose of quoting his method of using the *uterine douche*. He says, "For this purpose an apparatus was constructed according to the directions of the German professor, (Kiwisch,) with only a slight and important variation, consisting of a tin box, ten inches square, holding about four gallons, with an india-rubber tube, twelve feet long, attached to the bottom of the tin box by a screw and nut, and having a metallic tube, six inches long, affixed to its other extremity—the end of the metallic tube being fashioned like the nozzle of the common enema syringe. Instead of arranging the apparatus to act on the principle of the siphon, as recommended by Kiwisch, a stop-cock was adapted to the india-rubber tubing, about two feet from its metallic end. To put the apparatus in operation, the box must be suspended on a nail driven into the wall, near the ceiling of the room, say nine or ten feet above the floor; the india-rubber tubing must be screwed on, and the stop-cock turned, so as to prevent the flow of the water till it is wanted. The patient takes her seat on a stool placed in a bath-tub to receive the water, the metallic nozzle is introduced into the vagina, and in contact with the os uteri, and the tin box having been previously filled with water, the stop-cock is turned, so as to pour a continuous stream upon the os uteri until all the water in the

box is discharged." Prof. Miller uses the water warm at first, and, if need be, subsequently alternates cold and warm. In the successful case reported, the *douche* was used but once on the first day. On the second, third, and fourth days, it was used twice each day. On the fifth and sixth days he used warm, and then cold immediately after, using the warm and cold *douche* each twice each day when labor set in.

The fact that the *douche* will sometimes fail in inducing labor, and the number of times it has to be repeated before success crowns the effort, will always operate against this procedure. We prefer the separation of the membranes, which can be done at one sitting, is usually safe when properly performed, and is always successful.

Influence of the Mother's Mind on the Fœtus in Utero.—In the *Nashville Journal of Medicine and Surgery* for February, Prof. John M. Watson has an able article upon the influence of the mother's mind on the fœtus in utero. He believes the mother's mind may, under certain circumstances, produce changes in the organization of the embryo in her womb, and the reasons for his faith are well stated. We have not the space to follow his arguments, and will content ourselves with stating his fifth and sixth propositions: "5. The mind, when improperly employed, may develop premature puberty, premature ova, and premature menstruation, to which may succeed premature conception; and all the energies of both soul and body being directed to this uterine function, may not certain images, under strong mental excitement, be transferred to the embryo? Seeing that the mind can exert such remarkable and undeniable influences over the female organism, may I not add a sixth fact? 6. That the embryo is sometimes altered or changed in its organization in various ways, through the mother's mind or imagination; or shall we admit the influence of the mother's mind over her in every other respect, and then exempt the organization of the embryo from its influence?"

Transfusion.—In the *Chicago Medical Journal* for February, Prof. Brainard reports a case of amputation of the thigh in a feeble subject, in which life was temporarily saved by transfusion of blood. He says: "In order to obviate the danger from loss of blood, I had an assistant hold a bowl under the member at the moment of the incision; in order to catch the blood, and stir it, so as to separate the fibrin, the bowl was placed in another containing water at the temperature of 98°. When the bone had been sawed, and the small vessels secured, the patient appeared to be dying from syncope. I then fixed the tube of the transfusion syringe into the femoral artery where it had been divided upon the stump, and the syringe at the proper

temperature; I charged it with the defibrinated blood, which had been actively agitated, so as to be of a bright red color, and threw gently into the artery nearly all the blood which had been secured. A light tremulous movement followed, and for about a minute no change was perceptible; but at the end of this time the respiration and the action of the heart became more regular, and he was soon as well as before the operation. The blood thrown into the artery was just two ounces." We have space only to quote another practical remark in this connection. Prof. Brainard says: "The choice of the artery instead of a vein for the transfusion was made for these reasons: 1st. It obviates the danger of fibrinous clots passing to the heart. 2d. It diminishes the danger of air-bubbles passing to the heart. These are the great dangers of transfusion."

Chronic Rheumatism.—In the *Cleveland Medical Gazette* for February, Dr. G. L. Purdy has an article upon the treatment of chronic rheumatism with the *sulphurous vapor baths.* We give Dr. Purdy's method of using the bath: "I had my patient stripped to the skin, and seated on a tight-bottomed chair, thickly enveloped with flannel blankets from the shoulders downward. Place the blankets tightly around the neck, and have them fit snugly to the floor, around the patient's chair, but as far from it as you conveniently can, so there will be no danger of their taking fire from the flames of the sulphur. Now place under the patient's chair an iron vessel containing one-fourth of an ounce of sublimed sulphur of the shops, and upon the sulphur place a small piece of red-hot iron, and combustion immediately takes place. If the vapor should escape through the blankets too much, and thus annoy the patient, place more covering around him, or keep the vapor from the face with a fan.

"The patient should be thus vaporized 20 or 30 minutes, or until a very free perspiration is got up. If the sulphur burns out too soon, add some more. When the bath is discontinued, have the blankets removed, and the patient well sprinkled with half a gallon of cold salt water, and thoroughly dried with brisk friction, and placed in bed, warmly covered, for three hours. The bath should be used once every second day."

Dr. Purdy reports one case that resisted thorough treatment for five months, at the hands of all kinds of physicians, that was completely cured in two months, under the use of the sulphurous vapor baths, with the addition of no medicines, except what had previously been thoroughly and ineffectually tried. This is not new treatment; it has been recommended previously by several good prac-

titioners; but it is probable that it is too much neglected in this country. As an article of medicine, it is probable that sulphur receives too little attention. The late Prof. Physick used to say, "If sulphur were a dollar a pound, it would be a very popular medicine with the medical profession."

Water Dressings.—In the *Louisville Monthly Medical News*, for January, Prof. J. B. Flint has a very interesting article upon *water dressing in surgical practice.* We allude to this paper because it is well worth a thorough study. We have long since been convinced that patients have been unnecessarily troubled with counter-irritants, with the ostensible object of preventing suppuration, perhaps as often with injury as benefit. In synovitis and textural inflammations, we think that the soothing influence of aqueous vapor will prevent suppuration quite as often as blisters, &c. We would not be understood as objecting to blisters, and counter-irritation in general, but to the too exclusive resort to such means to the neglect of the more comfortable applications of appropriate water dressings.

Prof. Flint is much in favor of the "vapor dressings," and we quote the following as a very good way of applying them. He says: "No particular, in the details of the antiphlogistic medication we are considering, is more essential to its successful administration, than the careful expression of all superfluous water from whatever substance is used as the means of evaporization. We cannot too explicitly insist upon the understanding, that it is not the application of *water* that we prescribe, but *the vapor of water.*" * * * "An estimable lady, as ingenious as she is assiduous and gentle, in attentions to her sick friends, exhibited to me, a few months since, an improved method of preparing the epithem, in warm water or vapor applications. The folded flannel, of proper dimensions, is to be wrung out of cool or tepid water, and being spread out on a firm surface, the heated flat-iron of the laundress is moved over it till it becomes a receptacle of hot moisture, the nurse or attendant being thus spared the scalding and hurry attending this portion of duty to the sick, when performed in the usual way." We have often applied the wetted cloths to the clean top of the cook-stove, thus filling the cloths with hot moisture, with less trouble than in any other way. The wet cloths should always be covered with some retentive covering, or, what is better, oiled silk. "One of the most common mistakes respecting the practical use of water dressings consists in confounding their action with that of poultices." In applying the *vapor dressing* to wounds, he says: "A fold or two of patent lint, thoroughly moistened with hot water, are pressed

or wrung out, and quickly laid upon the diseased surface; a piece of oiled silk is immediately, but lightly, placed over it, and the dressing is complete."

Scarlet Fever.—Prof. J. W. Benson, junior editor of the *Louisville Medical News*, in the January number of that journal, has the following in regard to the treatment of scarlet fever: "In twenty-five successive cases of this disease, which have been latterly under my professional care, the treatment consisted in inunction of the parotid and submaxillary regions by an unguent composed of fifteen grains of the extract of belladonna to an ounce of simple ointment. This was applied freely and frequently as soon as the patient complained of sore throat. A piece of flannel was afterwards applied, and in no case was any other treatment adopted, except the administration of small quantities of neutral mixture during the day. In some cases of rapidly occurring tumefaction of the throat, the prompt subsidence thereof under the treatment left no room for doubt as to its efficacy. I do not pretend to offer this mode of treatment either as a cure for scarlet fever or as the sole means to be relied upon in any case, but I do claim for it a controlling power over the engorgement, and hence a prevention of those destructive ulcerations of the throat which are so much and so justly dreaded." From what we know of the effects of belladonna in the treatment of mammary inflammation, we should certainly expect benefit from this treatment in the glandular symptoms of scarlatina. In a severe form of any disease acknowledged to be constitutional, as is scarlet fever, we should never have sufficient confidence in any local treatment to the neglect of constitutional means. As an auxiliary to remedies of well-established utility, we hope much from the suggestion of Prof. Benson.

Asthma.—In the *Louisville Medical News*, for February, Dr. W. H. Newman has a paper upon asthma, in which some opinions are expressed differing somewhat from those usually received as true. He says he cannot believe that the dyspnœa, which is called asthma, "can be produced by a spasmodic constriction of the pulmonary air-tubes. I cannot believe that those tubes have the power of contracting by spasm. In fact, I doubt even if those tubes possess any muscular fibre whatever, entering into their composition." He expresses his belief that "asthma is not produced by a spasmodic constriction of the pulmonary air-tubes, nor by any nervous disorder, but is owing to some disordered state of the mucous membrane lining the air-tubes, and probably the pulmonary vesicles also, by which the free entrance and exit of the oxygen and carbonic acid are hindered or prevented." He

promises to give his views of the true pathology of this disease in a future paper, in which event we shall take pleasure in bringing the results before our readers.

Treatment of Epilepsy.—In the *Southern Medical and Surgical Journal*, for February, Dr. Trent, of Richmond, Va., reports two cases of epilepsy cured with the *hydrocyanate of iron.* His formula is the following:

R.—Hydrocyanate ferri,	3j.
Pulv. valerianæ,	3ij.

Make into pills, No. 120. Dose, one pill three times per day, gradually increased to four pills a day."

This treatment is not original with Dr. Trent, but, if we rightly remember, was first used successfully by Dr. McGugin, of Keokuk, Iowa. To the above formula one drachm of extract of cannabis indica is added by Dr. McGugin.

Dysentery.—In a clinical lecture in the Pennsylvania Hospital, by Francis G. Smith, as per report in the *Medical and Surgical Reporter*, saline cathartics are recommended. We quote from the *Reporter:* "In his own practice he had preferred to use Rochelle salt. Of this one ounce was to be dissolved in a pint of cold water, and a wine-glassful taken every hour until a bilious evacuation was produced. It was then to be stopped, and ten grains of Dover's powder given. This, in most cases, was followed by the cessation of the disease." * * * "Of the fact there was no question, that the saline treatment had proven more successful in his hands than any other."

Dr. Smith says that the treatment of acute dysentery was first proposed by a French physician some years ago. This may be so; but if so, the Frenchman's claim to originality must date back at least a quarter of a century.

In the spring of 1855 it was communicated in a letter to Prof. George Mendenhall, by Dr. D. B. Dorsey, both of Cincinnati. Dr. Dorsey said he had treated dysentery with saline cathartics, as specified in the communication, for more than *twenty years.* Dr. Dorsey learned the peculiar plan of treatment from Dr. F. Lemoyne, of Washington, Pa. Dr. Mendenhall published Dr. Dorsey's letter in the *Western Lancet*, for June, 1855. Ever since we commenced to treat disease, we have treated dysentery with cathartics and opiates. On reading Dr. Dorsey's letter, we were favorably impressed with the propriety of the proposed treatment, and disposed to give it a trial because he had used it for 20 years, and in two or three severe epidemic visitations of that disease, with only one fatal case. We have ever-

since relied upon it, especially in adults, and previously, on two occasions, have commended it to the profession.

As the formula under consideration differs somewhat from that used by Dr. Smith, and because it may be new to many of our present readers, we subjoin it here:

"R.—Saturated solution sulph. magnesia, f. ℥vij.
Aromatic sulphuric acid, f. ℥j.

Mix." * * "The medium dose of this medicine for an adult is one table-spoonful, diluted with two or three ounces of water, every four to six hours, until it gently moves the bowels." * * "Accompanying each dose, when the pain and tenesmus are great, one-sixth of a grain of sulph. morphia may be given." The dose of the mixture and of the morphine will both require variation to meet the wants of individual cases.

Scarlatina.—In the *Journal of Materia Medica*, for February, Dr. Joseph Bates has an article upon scarlet fever. We quote the following: "Dr. McGugin, of Iowa, in referring to the use of ammonia in this disease, says that instead of it, he has used, in an epidemic of scarlatina, during the present winter, chlorate of potassa, in combination with veratrum viride; it was of the anginose variety, and every case was controlled in a few days. He gave the veratrum with the solution of the chlorate, each in doses appropriate to the age of the patient, using the salt as a gargle. Dr. Bostwick mentions a number of cases attended with high fever, and pulse 120 to 140; some of them delirious on his first attendance. He treated all with veratrum and tonics, also applied sinapisms to the throat. In some, attended with cough and excessive secretion of mucus, he vomited the patient by one or two additional drops, with great relief. In several cases of this disease, which the writer has treated within a few weeks, all successfully, without witnessing one unfavorable sequence, he has relied mainly upon *veratrum*, *quinine*, citrate of iron, brandy or whiskey, nitrate of silver, and chlorate of potassa.

PROCEEDINGS OF SOCIETIES.

Medico-Chirurgical College. January 26, 1860. Dr. JAMES BRYAN, Chairman.

DR. LEWIS A. SAYRE, who was appointed to read a paper on *Morbus Coxarius*, stated that he had not prepared a paper on the subject, but would make a few remarks upon the disease, and explain an apparatus which he had contrived, to be used in the treatment of the same during its earlier stages. He divided the disease into three stages, as follows:

The *first* is the inflammatory condition of the disease, having its origin from a fall, blow, injury, or other extraneous accident, which will induce a synovial inflammation of the hip-joint, and occurring in a strumous constitution, will go on, unless arrested, until the cartilage and bone are involved; finally terminating in what is called morbus coxarius, and resulting in the deformity, anchylosis, or shortening which are peculiar to this disease—or death. The symptoms in this stage, such as pain in the knee, imperfect flexion, pain or pressure of the trochanter, or percussion of the knee, &c., &c., he would not dwell upon, as they were familiar to all. He would merely remark upon one symptom—that of pain produced by pressure, bringing synovial membrane in contact—that it was a remarkable fact, that in the healthy condition the synovial membrane bore pressure, without the least sensation, as proved by jumping from great heights and striking upon the heels, producing no pain whatever. Yet when this membrane is inflamed, the slightest amount of pressure produced the most intense suffering; and hence the necessity of *removing all pressure* from this delicate and sensitive membrane, when in a state of inflammation. This inflammation, unless arrested, will produce effusion, and if it be of much amount, will produce a *peculiar* deformity, viz.: an *apparent* elongation of the limbs; *eversion* and *abduction;* flattening of the nates; the rima nates on the diseased side being lower than on the sound side; flexion of the thigh on the pelvis, and the leg slightly flexed upon the thigh. If the effusion be excessive, or the inflammation acute, you will have an *apparent* anchylosis, caused by muscular contraction, which is an involuntary act, produced by reflex action of the inflamed or irritated nerves, *and is done for the purpose of keeping the joint perfectly still*; which is the indication for the surgeon to imitate this action, and accomplish this result, of *perfect rest* to the inflamed synovial membrane, by artificial means, and thus save the necessity of

this *constant* muscular effort, which, continuing day and night for months, eventually exhausts the system and brings on hectic fever.

The flexor muscles of the thigh, the tensor vagina femoris, the pectineus and rectus femoris are so firmly contracted that the whole pelvis moves on the opposite acetabulum; and you will distinctly see the ilium of the opposite side move, upon any attempt to rotate, adduct, or abduct the diseased limb. Even under chloroform this motion takes place, as I have seen in several instances.

This does not depend upon true or bony anchylosis; for by division of the flexor and adductor muscles, or by puncture of the joint, you will have free motion of the limb, showing that there has been no bony anchylosis. This is the *second* stage of the disease, and if it be not arrested, ulceration of the capsule takes place, and the fluid, whether pus or plastic lymph, becomes effused in the surrounding tissues, and in the majority of instances burrows in various directions, and finally produces an external opening—in different portions of the thigh—sometimes only one, but frequently more, and in many instances some distance from the affected joint. The capsule being thus ruptured, we have the *third* stage of the disease, and the peculiar change that takes place in the deformity occurring so suddenly has led to the false idea that a luxation had taken place. The limb is now apparently shorter, adducted, inverted, flexed in *hip only*—pelvis raised—projected backward; in fact, the position is almost the reverse of what it was in the second stage, and thus occurs *suddenly* upon the perforation of the capsule.

Second Stage.	Third Stage.
Limb (apparently) longer.	Limb (apparently) shorter.
" abducted.	" adducted.
" everted.	" inverted.
" flexed in both joints.	" flexed in *hip* joint only.
Foot touches the ground with sole.	Foot touches with ball only.
Pelvis lowered on diseased side.	Pelvis raised on diseased side.
" projected forward.	" projected backward.
Nates low and flat.	Nates high and round.
Pain most intense.	Pain greatly diminished.

TREATMENT.

In the treatment of this disease, in its first stage, local depletion, by leeches or cups, is often necessary, with a relaxed condition of the bowels. But the most important of all, and on which all prospect of success will depend, is *rest of the joint*, and *perfect freedom from pres-*

sure of the synovial membrane, together with such constitutional remedies and general support of the system which we find requisite in all strumous diseases. The use of issues, at this stage of the disease, as formerly employed, he condemned, as they often aggravated the disease, if they did not hasten the death of the patient. When left to itself, the rest which is so essential to the joint is procured by the firm muscular contraction which prevents the motion in the joint, and is so perfect, as in many instances to assume the appearance of genuine bony anchylosis. But this *constant muscular contraction* exhausts the nervous system, and induces hectic fever; gives the child nocturnal spàsms, of intense agony; prevents nutrition of the limb, which results in atrophy. We therefore resort to artificial means to produce this rest, and divide the firmly contracted muscles, to prevent the head of the bone from being pressed against the acetabulum.

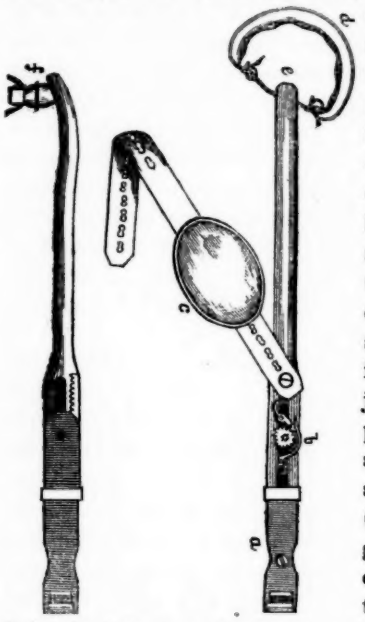
I have treated a number of cases in this way, after the plan of Dr. Bauer, of Brooklyn, with the happiest results; using as a means of rest and extension his "Wire Breeches," an apparatus for the treatment of this disease, in some of its stages, which is far superior to any other that I have ever seen or heard of.

The great difficulty to be overcome in securing *entire rest* of the joint, is the danger of producing bony anchylosis, resulting from the general inflammation of the surrounding structures, and sometimes great stiffness and partial anchylosis of the well joints. On the other hand, if we remove the instrument, and commence passive motion, *without keeping up extension*, there is danger of reproducing the inflammation.

I have, therefore, come to the conclusion that *perfect rest*, however essential it may be to an *inflamed synovial membrane*, is not only unnecessary to the ligaments, (which, in the earlier stages, were not involved in the inflammation,) but was positively *physiologically wrong*. As the eye needs the healthy stimulus of light, so does the ligament need the stimulus of *motion*. If, then, we can give motion to the ligaments of a joint, while at the same time we prevent muscular contraction, so as to remove pressure from the synovial membrane, we shall accomplish our object, and at the same time give the patient the benefit of out-door exercise, which is so essential in this disease.

He has tried to make an instrument by which the muscles can be overcome, while at the same time a certain amount of motion is given to the limb, and practically it answers every purpose. In the few cases in which he had used it, it has answered more than his expectations, the patients begging to have it reapplied whenever it has had to be removed, for repairs or any other purpose.

The instrument shown was constructed under his direction, by Mr. Ford, of No. 85 Fulton Street, a most ingenious mechanic, and



one of the few surgical instrument makers who is willing and able to practically construct what you may originate or devise. The instrument consists of a steel bar, one and a half inches wide, (see cut,) extending from above the ilium to the external malleolus, slightly curved inward at its upper extremity—at its upper extremity there is a ball and socket joint, (concealed at *e*, visible at *f*,) resembling the hip-joint, and a pulley over which plays a catgut, which is fastened at either end to a piece of firm and strong india-rubber tubing, (*d*,) which passes around the groin, and makes the means of counter-extension; adhesive plaster spread upon firm inelastic cloth, about two or three inches wide, extends from the trochanter major to the external malleolus, and is closely secured to the limb, by plaster and a roller, for the purpose of extension. This plaster is sewed fast at its lower extremity to a piece of webbing or belt, which plays over a roller in the lower extremity of the steel shaft, (*a*,) and is firmly secured by a buckle a few inches above its lower extremity. The steel shaft consists of two pieces, the one sliding into the other, and capable of being extended at pleasure, by a ratchet and cog-wheel, (*b*,) worked by a key, and retained at any position required, so that the extension and counter-extension are perfect, and entirely within the control of the surgeon. There is also a knee-cap (*c*) and strap intended to pass over the knee, and around the limb, to assist in sustaining the limb in position.

As the disease is one which requires many months for its treatment, it is necessary to keep up the extension, and increase the length of the instrument just in proportion to the growth of the child. As children generally grow from three to four inches in a year, or at the rate of about 1-16th of an inch a week, the cogs and ratchets are cut so

that they extend the instrument that distance at every single turn. The surgeon can therefore move it one cog every week, more or less, as his judgment may dictate. By the use of this instrument with leeches and iodine to the joint, combined with constitutional treatment and support, I have seen cases terminate before passing to the second stage, and recover without deformity, and with perfect motion.

When the disease has gone on to the *second stage*, and there is extensive effusion in the joint, which cannot be absorbed by the use of iodine or blisters, I should then puncture the joint, and allow the parts to resume their natural position, and then apply the instrument; by which means the necessity of dividing the tendons will be avoided in many instances, as the india rubber, by the *permanency* of its contraction, will overcome the muscular rigidity. At least it has done so in the few cases in which he has tried it.

If it did not, he would at once resort to myotomy, as nothing will so quickly relieve the agony of the patient as the division of the contracted muscles. Another advantage derived from puncturing the joint is in our diagnosis: when the joint is distended, we can get no crepitus, and cannot tell whether the cartilages are destroyed, and the bone is bare or not; but as soon as punctured we can ascertain the fact with positive certainty. And if the disease has so far progressed that you get *positive bony crepitus*, in other words, you have dead bone within the ligament, he is positively convinced from experience that the only proper treatment is immediate *exsection* of the dead bone. All delay, after you get *bony crepitus*, is but to the detriment of the patient; for if you wait too long there is danger that the acetabulum will be perforated, and pus escape into the pelvis. The sooner exsection is performed the better, and the advantage we gain in diagnosis, by puncturing the joint, more than compensates for the risk of the operation. In fact, done with proper care, there is not much risk. Dr. Bauer, of Brooklyn, has punctured the hip-joint now more than fifty times, and as yet without a single accident.

The operation of exsection is attended with no especial danger, and almost no hæmorrhage; it is a trifling operation compared with exsection of the knee or elbow. The results of the operation have been very remarkable indeed, when we consider the circumstances under which they have been performed. All the fatal cases that he had been able to trace had been performed too late; the acetabulum perforated, fragments of bone left behind; and in one instance no extension was used, and the sharp end of the femur perforated a blood-vessel, causing death by secondary hæmorrhage. In cases where the operation has been

performed at the proper time, and the proper treatment pursued afterwards, the success has been very remarkable; in many cases the patient recovering with considerable motion of the limb. The patient on whom he performed this operation, the first ever performed in this country, now some seven years since, he saw not long since *jumping a rope* as lively and strong as any child. She has only about an inch or an inch and a quarter of shortening, and has every motion of the joint perfect and complete.

Dr. O'Reilly remarked that he agreed entirely with Dr. Sayre in condemning the use of issues in this disease, and had endeavored to point out the mischief resulting from their application, in a paper published in the *Medical Gazette*. He would also state, that he was in the habit of treating this disease successfully, in many cases, without deformity. He depended mainly upon the plan of treatment laid down by Dr. O'Burns, of Dublin, in 1843—namely, the use of mercury. Dr. O'Burns also recommends that the patient should be kept in a quiet position from four to six months, but does not advise anything in the shape of a splint. When the disease has advanced to the second stage, Dr. O'Reilly combines with the mercurial some *tonic* remedy, such as the compound tincture of bark, together with cod-liver oil, so as to remove the scrofulous taint, and build up the system. Under this treatment, he thought that most of the cases improved, while some recovered with almost no appreciable lameness. In one case, that of a little girl, put under this treatment, the recovery was complete; she is now a fine, stout, healthy girl, and has scarcely any deformity whatever.

Dr. Raphael thought that too little importance had been attached to the use of the bichloride of mercury in this disease. He considered it as one of the most valuable remedies in the whole Materia Medica, not only in this disease, but in many others in which it was formerly used, where it now seems to have been abandoned. Secondary syphilis is one of these; he considered it as a most valuable remedy in this affection. With regard to morbus coxarius, he would say that he himself had had the disease, and was treated with the bichloride of mercury, which perhaps might account for his strong partiality for this remedy. He knew very little about the history of his case, except what he had learned from his parents; and their statements led him to believe that the disease advanced to the second stage, as he was confined for some time. With regard to the present condition of the joint, he thought that he had a subluxation, resulting from partial absorption of the acetabulum, so that the head of the

bone rests upon its upper edge. When he moved the affected limb, he could feel the head of the bone slip out of the cavity. He is unable to cross the leg completely, but has anterior and posterior motion perfectly. There is about one-half inch shortening, which he has remedied by placing an inside sole in the boot of that side. To the local treatment in his own case he did not attach much importance; he considered that the beneficial results were almost solely attributable to the constitutional treatment employed; he could not, therefore, viewing not only his own case, but many others, avoid being impressed with the necessity of using constitutional remedies, and more particularly the bichloride of mercury. Dr. Raphael then requested Drs. Sayre and Carnochan to examine his case, to see if the diagnosis was correct.

DR. GARDNER then remarked that he was prepared to place great faith in the apparatus of Dr. Sayre, from what he had seen of treatment of diseases of the spine by the instrument of Dr. Davis, which is so constructed that, while it permits a certain amount of motion, it prevents the two bodies of the vertebræ from pressing against one another; thus permitting the patient to take exercise. He had also used the bichloride of mercury in this disease, and had more faith in it than most other preparations.

DR. SAYRE, who meanwhile had examined the case of Dr. Raphael, stated that in his opinion there was no subluxation, or destruction of the joint. The half inch of shortening he thought resulted from a lack of nutrition in the affected limb, during the active stage of the disease, while the other went on increasing in size; a circumstance which he had noticed in other cases. There is some grating motion in Dr. R's case, and it is quite probable that the cavity of the acetabulum is partially filled with plastic effusion, preventing the head of the bone from fitting the cavity, and as it rises over these points, gives him the sensation of subluxation.

DR. SELDEN stated that he had used the bichloride of mercury in the hospitals on Blackwell's and Ward's Islands, and had seen no great benefit result from its use. He gave the preference to iodide of potassium, even where the patient has had syphilis in early life.

DR. O'REILLY did not consider this any argument against its use in morbus coxarius.

DR. CARNOCHAN remarked that, in a disease like morbus coxarius, which naturally runs through a period of time ranging from six months to two or three years, you can scarcely expect to bring the treatment of the disease to a unit. Morbus coxarius is in fact a se-

ries of symptoms, and to say that issues or any other form of treatment is not applicable to the disease, *may* or *may not* be true. It may depend upon the stage of the disease in which this particular treatment may have been tried, whether it failed or succeeded. Morbus coxarius begins as an acute disease, as a phlegmasia, and is to be treated as such. It is, however, associated with a taint which makes a difference between it and ordinary inflammation. There must be, then, a treatment for this peculiar phase of the disease. The disease at this stage, if left to itself, may end in resolution, or it may go on to the formation of pus. Here, then, we cannot say that *one particular* form of treatment is *always* applicable; and so it is with the third stage. So, when we speak of the treatment, we must also speak of the *particular condition* to which this treatment is applied. Hence I think that a great many mistakes have been made with regard to the treatment of morbus coxarius, and hence the confusion with regard to the essays which have been written upon it. The two great principles at issue with regard to treatment of morbus coxarius are: one, to secure rest by mechanical means; the other, to allow the patient to follow the laws of instinct. I think in such cases the more favorable plan is to allow the patient to follow his own instinct, without the use of any apparatus whatever. In some twenty cases where the patients were allowed to follow their own instincts so far as motion was concerned, the result was favorable; they all got well. The plan of Dr. March, of Albany, is to draw the head of the bone from the acetabulum, and then confine the patient to bed. I know of two cases treated in this way, and in both the treatment failed to bring the disease to a successful issue. The discussion of this subject, so far, has been too *general*. One gentleman tells us that the application of issues is wrong, while Dr. Sayre says that the muscles must be divided. What we want is the *phase* of the disease to which these different kinds of treatment are applicable. So far as the nature of this affection is concerned, I have been in the habit of looking upon it as a constitutional disease. It is a strumous affection; I would almost regard it in the same light as strumous ophthalmia. I have consequently, in the treatment, relied very much upon constitutional measures. In the first stage of the disease, as much quietness of the parts as possible should be enforced; as a general rule, the patient will, if left to himself, assume instinctively that position which will give rest to the joint. Dr. Physick was in the habit of applying an apparatus for the purpose of keeping the joint at rest. At the present day, we have the apparatus of Dr. March, which is recommended by some;

then we have Dr. Sayre recommending puncture of the joint. These methods are but matters of experiment as yet. So far as the discussion has gone, we have no precise data. I might mention, as still leading to further discussion, the usual plan of treatment which I have adopted. In the first stage of the disease, I now use mechanical means of a gentle character, such as splints of *pasteboard*, for the purpose of maintaining the joint at rest. The joint is kept at rest in this manner for three or four months; in the mean while I deplete, or rather *revulse*, by acting on the intestines with doses of rhubarb, soda, and ipecac; at the same time I give the child such a diet as can be taken and *digested*, but do not attempt to *force* upon it any form of nutritive material. I order such articles in the way of food as eggs, beef-tea, soup, etc., in just such quantities as the *child will partake of them;* and if this stage ends in resolution, there is an end to the case. I have been fortunate enough to have this occurrence take place in many cases.

Sometimes, however, no treatment appears to be of any avail; the case then progresses to the suppurative stage. *Now* is the time for counter-irritation; the disease is now chronic. The irritable pulse of the inflammatory stage is not present; you want then some counter-irritation applied near the part, not sufficient to increase the *general* irritation; not to make a point of irritation from which there will be communicated a general irritation to the whole system, but just enough to act as a *flux* from the diseased part. There is no doubt that the old doctrine, "*ubi irritatio ibi fluxus*," is true I think that all experience will prove that *that* is correct. I usually effect the counter-irritation by means of the "actual cautery," applying it midway between the tuberosity of the ischium and the trochanter major. In the first stage we deplete, to revulse upon the joint; but in the second stage, where the disease has become passive, where suppuration is about to take place, or where it *has* taken place, counter-irritation is to be resorted to; it must not, however, be carried too far; you cannot afford to draw away so much as to prostrate the general vitality, but just enough to produce a flux from the part. The second stage may be treated successfully, or it may not. If *not* treated successfully, what takes place? You have pus forming in the joint; you have the capsular ligament perforated by ulcerative absorption, and matter finding its way into the joint; you have abscesses forming round about the joint. Here is another phase of the disease; what are you to do now? Are you to continue the issues, or are you to leave them off? Are you to open the joint or not? These are knotty points in pri-

vate practice; for when the joint is opened and the matter let out, even in the most cautious manner, we often have irritative, and finally hectic fever, setting in; and we have such men as Abernethy laying down rules by which this irritative fever may be prevented, thus recognizing it as a consequence of the operation. Again the question comes up, Shall we open the joint freely, or give exit to the matter by subcutaneous puncture? These are points perhaps not yet *permanently* decided. Will a section of the muscles have much effect in this second stage? How many muscles do you have to divide? Not only the rectus, gracilis, sartorius, and other muscles in front, but also those which run from the tuberosity of the ischium to form the ham-string and the gluteal muscles. It may be very well to ask what is to be the influence of this traumatic lesion from cutting so many muscles? But let us go on to the third stage, where the disease is still, and attended with no effusion at all, and with very little pain, the patient being perhaps able to jump about, or even to run about the streets. Here we have the matter running from sinuses formed about the hip-joint. Here is another phase of the disease, and no one supposes that issues will be of any benefit at this period of the disease; so when we speak of morbus coxarius, we must take it up seriatim, not as a unit. Exsection has been spoken of. I can imagine very well that in certain periods of the third stage the head of the femur may be cut off with advantage; but are we always to be in a hurry to cut off the head of the femur? I should say it would be better to wait a little before we undertake such a serious operation, because the disease sometimes goes on much more favorably than we supposed it would, if we let it alone. The doctor has also spoken of puncture of the joint in the early stage, and subsequent application of the instrument. So far as puncture of the joint is concerned, I should hesitate very much to perform it in private practice, for fear that inflammation of the joint would follow.

Dr. Sayre said it was chiefly in the inflammatory stage that he expected benefit from this instrument, applied so as to get freedom from pressure on the infra-synovial membrane, while at the same time you give the child the benefit of exercise. Some of the treatment as laid down by Dr. Carnochan, varying according to the several stages, is very properly and very judiciously viewed, particularly as he now recommends the pasteboard splint in the early stages for some months, to keep the limb quiet, rather than to leave the patient to the *instincts* of nature; but he (Dr. S.) was not prepared to entirely agree with him in some points. He asks, if the disease goes

on to the second stage when there is effusion in the joint, whether it would be well to puncture. He should reply, if we fail entirely in producing absorption of the fluid by the use of remedies, then, rather than have the joint perforated by ulceration, he would make a valvular puncture, and withdraw the fluid, and would have little fear of constitutional symptoms. Of course, the operation is attended with some danger, as are all operations, no matter how slight, in children. In regard to division of the muscles, the necessity of dividing the gluteal has been referred to. This, he said, was not exactly according to his experience. In the second stage, the thigh is flexed upon the pelvis by the rectus femoris, and abducted, lifted outward by the tensor vaginæ femoris. The gluteal muscles exercise almost no influence. On examining the gluteal region, you find the nates flattened, and the muscles loose and flabby. In some cases we find the tensor vaginæ femoris so firm and hard, that it almost obliterates the ant. sup. spinous process of the ilium, the difference on the two sides being very marked The pectineus and gracilis will be found very firmly drawn in the other direction. To restore the limb to its position, it is only necessary to divide *those muscles* which are *firmly* and *rigidly* contracted. The treatment by division of the muscles, in cases where the patient is suffering the most intense pain, where the disease has gone on to the suppurative stage, has been followed by the most perfect relief from all *pain;* the suppuration, of course, goes on as before, but *sleep* can be had without anodynes; the appetite is restored, and the general condition of the patient improved.

In the third stage of the disease, no one would attempt to get into the joint by puncture. Where the joint is destroyed, where naked bones come in contact, and pus is endeavoring to escape, rather than let it alone, he would make an incision *fairly* and *fully into* the joint; no valvular incision, but one by which the air can get in and *out* again; nothing need be feared from the introduction of air, for it is a *joint* no longer —it is no more entitled to the name of a joint than any other portion of dead bone, and he would therefore cut down to it, and remove it.

DR. CARNOCHAN remarked that he did not consider the bone as *dead*, but only in a *carious* condition. If the bone were dead, it would assume the character of a sequestrum, and be thrown off. Unfortunately the bone is still living, but carious. We know very well that caries of bone ends in resolution; we see this in the spine, where, in the course of time, the disease terminates by bony anchylosis. We have this same condition of things about the joint; the bone is in a carious condition. The question is, whether it is proper to cut away

the head of the bone, or to leave the case to the recuperative power of the system, influenced by therapeutic means, properly directed? Again, if the head of the femur were situated like the head of the humerus, the operation might be more practicable, but we cannot chisel out the bone as we wish without being liable to create suppurative inflammation of the pelvic structure. He would therefore be unwilling to adopt this practice, because we know the disease will get well with anchylosis; sometimes the surfaces become ebernated, forming a sort of a joint, and allowing motion even after the third stage.

Dr. Sayre.—If this dead bone is allowed to remain, there is danger that it will create disease in the acetabulum, and then the case is almost hopeless, and the operation would be, perhaps, followed by fatal results. The operation, to be of benefit, *must be performed* at the *proper time.* One more point—he thought the removal of the dead bone from the hip-joint is just as proper as the removal of the head of the humerus, and certainly more necessary. The acetabulum is a delicate structure, thin in its inner and pelvic wall, and may become perforated —a piece of dead bone may remaim in the glenoid cavity for years without producing any serious result; not so, however, with the acetabulum.

Dr. Carnochan asked Dr. Sayre what he would do in the case of a child of about 12 years of age, who has passed through the different stages of the disease, and is now in the following condition: The tissues about the part are somewhat thickened; there are two sinuses leading to the diseased joint, which throw out, not exactly pus, but sero-purulent matter in no very great quantity. The child is able to be up, walks about, sleeps well, the limb is slightly bent inward, the head of the bone seems to be relieved in a certain position, and the child instinctively assumes it. There is no anchylosis. This is a case which might get well without treatment other than therapeutical.

Dr. Sayre —Did you find crepitus?

Dr. Carnochan.—Crepitus could not be detected, but the probe leads down to dead bone.

Dr. Sayre.—If dead bone could be found, and I could not remove it by dilating the sinuse with compressed sponge, I would cut down and remove it, just as I would anywhere else. In many of these cases, there is an inflammation of the periosteum of the femur, and no implication of the joint; the periostitis and necrosis, involving only the upper portion of the femur, the joint, proper, having entirely recovered its healthy action; in these cases, I presume Dr. C. would make no

objection to exsection of the dead portions. He could see no reason why the same rule should not apply, where the *dead portion is embraced within the capsular ligament;* but, on the contrary, every reason why it should be *more speedily* removed, than where it only involved the shaft of the bone; for, within the capsule, it endangered the perforation of the acetabulum, and consequently the pelvic viscera.

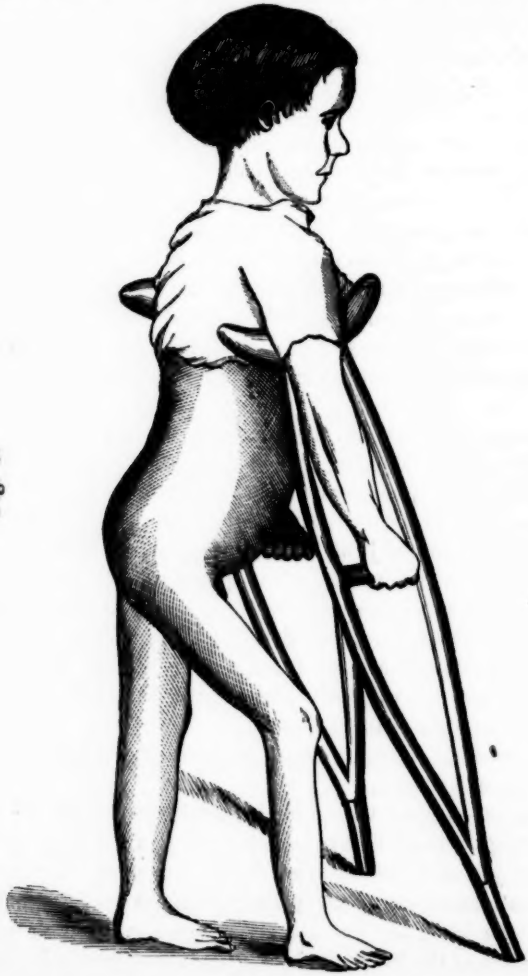


Fig. 1.

Photographs taken by M^r^. Gurney, of a case of morbus coxarius,

with and without the instrument applied, were then shown to the College. The accompanying cuts were reduced from these photographs. Fig. 1 shows the malformation, and the position the patient naturally assumes in the first and second stages of the disease. Fig. 2 is the

Fig. 2.

same case with the instrument applied; shows the method of its application and the improved position of the patient, as the result of the use of the instrument. The two photographs were taken within twenty minutes of each other.

EDITORIAL AND MISCELLANEOUS.

— The paper which we publish this month upon *Osteo-Plastic Operations*, from the pen of one of the most distinguished surgeons of the age, Prof. Langenbeck, of Berlin, is upon a subject of the very highest importance. The recent researches of M. Ollier upon "The Artificial Production of Bone, by means of the transplantation of the periosteum, and the regeneration of bone after exsection, and complete removal," which have been doubly crowned by the Academy of Sciences and the Academy of Medicine, have opened a new avenue for surgical exploits. The report of the several successful operations given in this paper is the legitimate result of the experimental researches made by M. Ollier. The application to man of the physiological data derived from experiments upon animals, is a brilliant suggestion in the direction of conservative surgery, and will tend to lead surgeons still further towards the preservation of form, in operations requiring extensive mutilation, such as was formerly the case in operations similar to those related in the paper given in the present number of the MONTHLY.

In this connection, we may state that M. Ollier has added another experiment in relation to the transplantation of bone, to those already given in his Essay, which appeared in Brown-Séquard's *Journal de la Physiologie.*

M. Sedillot, of Strasbourg, in a note addressed to the Academy of Sciences in December last, denied that there was any well-authenticated case of complete osseous regeneration under the periosteum, sufficiently produced to replace the ancient bone and fulfill its functions.

In reply to this, M. Ollier cited, in a subsequent sitting, several cases drawn from the practice of experienced surgeons, to sustain his views, showing that the movements were preserved, and the various functions of the original bone maintained. At a still more recent sitting, M. Ollier contributed a note upon the transplantation of bone taken from animals dead a certain length of time, which goes to show still more forcibly the remarkable aptitude which these tissues have to unite. "Not only has he transplanted entire bones immediately from the midst of the tissues of a living animal, but he has succeeded in reviving them upon another animal of the same species, although the animal from which they were taken had been dead some little time." "The vitality of these tissues," says M. Ollier in this note, "is not extinguished with the circulation and respiration; transplanted into a

situation analogous to that they formerly occupied, they continue to live and to grow to a certain degree, according to the laws of their normal development."

"Portions of periosteum taken from rabbits which have died either from hæmorrhage, or from a section of the medulla oblongata, were engrafted, and gave osseous productions ten, thirty, sixty and eighty minutes after the heart had ceased to beat. Entire bones, (humerus, tibia, radius, &c.,) transplanted ten, thirty and sixty minutes after death, united perfectly. In these different experiments the union was real; since the transplanted bones presented, at the end of five months, the following characteristics: They were perfectly adherent to the tissues in which they had been placed; they were covered with a subperiosteal osseous layer of new formation; they were permeable to injections thrown in by the arteries."

M. Forget, in reviewing the subject in the *Union Médicale*, for February 21, thinks that the formula laid down by M. Flourens, to the effect that, "preserving the periosteum upon removing a bone, the preserved periosteum will *produce bone*," should be so modified as to read "will produce bony tissue." This is quite sufficient for all surgical purposes, and until experiment proves demonstrably the aphorism of M. Flourens to be correct, we shall be content to accept the modification, not regarding it as in any way interfering with the great practical results to be drawn from it, for the use of the bold surgeon.

— Dr. Wm. F. Holcomb, to whose kindness we are indebted for the paper by Prof. Langenbeck, informs us that the translation was revised by Prof. Langenbeck himself.

From the letter which accompanied the paper we select a few paragraphs, as they afford important information relative to the various schools of Europe, judged by one who has at two separate visits passed several years among them.

Dr. Holcomb writes us, "that if a young man calculates to reap much advantage by coming to Europe and staying here and there, 'on the wing,' and returning home in a year or eighteen months, as so many do, he greatly misapplies his time and money. An American doctor—just '*fledged*'—had better spend a year in the hospitals of any of our large cities (if he has not done so) before coming to Europe; and unless he can speak or understand perfectly French and German, or can stay two or three years in Europe, he had better not waste his time or money by going to Paris or Germany. I have found Dublin to be the best place for American doctors who come abroad to stay a year

or so, though its advantages are seized by a few only. The Dublin Medical and Surgical Professors are the best educated, accomplished, noble gentlemen I have yet seen anywhere, and the advantages for hospital study in Dublin are almost unlimited.

"I think the advantages in Germany for the study of Pathology, Physiology, and Microscopical Anatomy are far superior to those in France, but a man must make up his mind to go *slowly*—as the German always does—but, nevertheless, most *surely*, towards a thorough knowledge of what he studies. Berlin, Vienna, Würtzburg, Erlangen, each have their advantages. Graefe, of Berlin; Donders, of Utrecht; Arlt, of Vienna, are the great teachers of ocular diseases. Virchow is the great pathologist of the day, though he is still a young man—under 40. He certainly has very great power in grasping facts, and distinguishing quickly political, religious, or physiological truths or fallacies. He is as great a Republican as he is a Physiologist. He has promised me a photograph of the Pathological Institute here, and with it I will send you a description of the same, and the plan of study here. It is most perfect, and one *must* learn if he wishes to."

Employment of Blood as Food.—We certainly live in an age of projects and suggestions, and we must be very blind to what is going on in transatlantic countries, if we imagine that cisatlantic ingenuity is only employed in producing innovations upon the customs and habits of the world. In all honesty, this *is* a fast age. Everything is made *to pay*, in some way or other. Inaction is considered the great crime, and less than six per cent. a poor return for any venture. Hear the French journalist, Guérolt, in the *Opinion Nationale*, as he talks of the new pamphlet of Dr. Steinroth—from the sober land of Germany—entitled *De la chair coulante et de son exploitation rationnelle.*

"The *chair coulante* (liquid flesh) is the blood. The German economist pretends that, despite our advanced civilization, the agricultural arts are yet in their infancy, and that real economical zootechny is yet to be created. We have dairies which abundantly furnish all European countries with milk; but meat is deficient, and its price becomes higher and higher every day. There are, moreover, in Europe three or four times as many beeves as cows. Let us, then, establish *laiteries de chair*, (dairies of blood;) let us obtain from animals their blood as we do their milk. Blood contains no gelatin, and but little fatty matter—still it is composed of all the other substances which make flesh *par excellence* the nutrient food. It is true, one cannot bleed beeves as often as we can milk cows, yet bleeding can be repeated weekly, and for several years, on the same animal without injuring its

health, and without removing the flesh, which we shall get afterwards. Thus we may obtain from a beef, a sheep, or a hog, three or four times as much alimentary material as we obtain now by slaughtering them. The blood could be eaten crude or cooked, pure or mixed with milk, or introduced into vegetable food, especially bread and pastries."

"The proceeding is not new. In Sweden, blood is employed in the preparation of a species of biscuit; in Ireland, (*sic!*) the poor frequently bleed beeves and cows to procure that substantial food which is otherwise denied them. In Africa the custom of using blood is quite extensive, and blood is the principal nourishment of a large number of people; like the Adjeba of the basin of Sobat, who only rear large herds for the purpose of subjecting them to repeated bleedings."

Guérolt adds: "We doubt, notwithstanding the arguments employed, whether this system of economical zoology will ever be adopted in France. The dairies of *chair coulantes* may be very highly appreciated among the negroes of Soudan, but in Europe there is an instinctive repugnance to the use of blood."

The editor of *L'Union Médicale* says this repugnance is not so great as might be supposed. *Boudin* (blood-pudding)—a very popular food—is almost exclusively made of hog's blood. In all the central provinces of France, the blood of almost all the fowls killed is carefully preserved, and, by means of a very simple mode of preparation, is fitted for the table. We understand how one could advantageously introduce, as food, blood of animals slaughtered by the butcher, which is now employed for other purposes, but we object to the proposition of Steinroth; it is a barbarous and cruel practice.

Who will make the effort to introduce blood on this side of the great ocean; who will establish a *blood dairy*? Shall the Rhine take the lead in this matter? Oh that Soyer were now alive! How many dainty dishes would he *compose*, the central and attractive feature in each of which should be *chair coulant!* We shall keep our eyes open to report the progress of the blood movement, although we fear some friends of the animal kingdom may strongly oppose the idea of keeping herds of beeves simply for the purpose of performing weekly venesection upon them. L. H. S.

— The Organoscope is the name which has been given to a new instrument which promises to be of great service in medicine and surgery. It has been highly spoken of by M. Velpeau and other eminent Parisian authorities. Its object is to convey into the natural or pathological cavities of the human body a light, which, without burning the patient, shall facilitate exploration. For this purpose, a

hollow glass tube is bent in the form of the letter Y, the two branches of which receive at their bulbous extremities the poles of a voltaic pile. The stem of the Y contains exhausted capillary tubes, which become luminous when the electric current traverses them. This stem is introduced into the cavity which is to be illuminated.

At the meeting of the Académie des Sciences, on the 22d of January, M. Fonssagrives presented a paper, of which the following is a translation:

I have long entertained the conviction that the electric light could with advantage be used in certain diagnostic examinations, and in certain surgical manipulations; for the ordinary methods of throwing light on the parts are either inadequate in intensity and in luminous radiation, or defective, in consequence of the color of their light. Besides, they are troublesome in other ways, for it is impossible to use them without hiding from view the surgeon's field of action, and it is necessary, from the great heat they give out, to hold them at a considerable distance from the surface requiring to be illuminated. Our problem, therefore, reduces itself to these three conditions: First, the luminous body required must produce little or no calorific action. Secondly, it must be capable of being condensed in tubes of minute volume and slightly varying form. Finally, the light itself must be extremely white, so as not to change the color of the organic tissues on which its rays are thrown. Thanks to the co-operation of Messieurs Du Moncel and Ruhmkorff, the problem has been satisfactorily solved. Having observed that the vacuum tubes of Geissler do not become heated under the influence of the electric light when traversed thereby, and knowing, moreover, that this light itself is more brilliant in proportion as the tubes connecting the terminal bulbs of the apparatus have a more minute diameter, M. Du Moncel thought that by taking an apparatus of this kind, in which a long tube, almost capillary, was bent upon itself and twisted like electro-magnetic multipliers, he could obtain not only a kind of luminous cylinder capable of being introduced into very narrow cavities, but also a sort of electric lantern, in certain parts of which light might be concentrated, without danger of producing heat or trouble. The first two conditions of the problem were thus satisfied. As for the color of the light in these tubes, it is well known to depend altogether upon the nature of the gas on which the vacuum was produced—being white, with certain mixed gases, such as carbureted hydrogen, carbonic acid, muriatic acid, etc. The last condition of the problem, therefore, is satisfied, if the tubes be prepared with the right kind of gas. M. Ruhmkorff, to whom the making of the tubes was intrusted, has attained a very satisfactory result; and experience has demonstrated the fact, that the light supplied by this apparatus is more than sufficient for the requirements of medicine and surgery.

Without wishing at present to trace out the precise applications to which this new method of illuminating organic surfaces is applicable, we may, however, indicate the following: First, it is a means of diag-

nostic exploration, and of examining the accessible cavities of the body, that their normal or pathological state may be ascertained. Secondly, it is a method of illuminating the parts during surgical operations.

The utility of this new instrument is obvious in operations in which the most serious contingent difficulties are complicated and increased by the impossibility of properly illuminating the surfaces on which the instruments are used. I may mention amongst those likely to profit in an especial manner from this new application—1, Staphylorraphy; 2, The operation for vesico-vaginal fistula, according to the American method; 3, The extirpation of uterine or naso-pharyngeal polypi; 4, The excision of the tonsils.

Moreover, certain operations in dental surgery appear likely to borrow from this mode of illumination conditions for their better and more easy performance. I may also ask whether these luminous tubes would not light up in a more complete and easy manner the field of the retina.—*Revue de Thérapeutique, 15 February*, pp. 103–4.

— Since our last issue, the Medical Schools in this city have all closed their winter sessions. The New York Medical College held its Eighth Annual Commencement on Thursday evening, March 1. The regular degree of Doctor in Medicine was conferred on *twenty* candidates in course, and the honorary degree on Samuel T. Parker and Campbell Morfitt, of New York; Thomas Garrett, of Pennsylvania; and Rev. A. G. Shears, of Conn. Samuel J. Tilden, Esq., delivered the Valedictory Address.

The *New York University, Medical Department*, held its Commencement on Wednesday evening, March 7. There were *one hundred and thirty-eight* graduates. Prof. Valentine Mott gave the Valedictory Address.

At the Commencement of the College of Physicians and Surgeons, which was held the evening of March 8, there were *fifty-five* graduates. Dr. Seth Lyman Chase, one of the graduates, delivered the Valedictory to the Class, and Prof. T. W. Markoe delivered the Address to the Alumni.

— *University of Maryland.*—Fifty young gentlemen received the Doctor's Diploma at the late Annual Commencement of this venerable school. The Chair of Anatomy and Physiology, vacated by the resignation of Prof. Joseph Roby, has been offered to Dr. William A. Hammond, Surgeon U. S. Army, who has accepted the offer, and will enter upon his duties with the commencement of the next session. Dr. Hammond is well known to our readers, as the author of the Essay on "*The Nutritive Value and Physiological Effects of Albumen, Starch and Gum, when singly and exclusively used as Food*," to which the prize was awarded at the Tenth Annual Meeting of the American

Medical Association. We wish him every success in a field of labor so congenial to his tastes.

—It is with sincere regret that we announce the death of one of our friends, Prof. Charles Frick, of Baltimore, whose name is familiar to the profession throughout the country as an earnest student, and who, among his personal acquaintances, was universally esteemed as a true physician and a noble-hearted man. He died in the active duties of his profession, from diphtheria, claiming for himself, as a relief from suffering, the operation of tracheotomy, which he had himself performed upon a patient, at the Infirmary, but a few days before. The following just tribute to his memory we take from a Baltimore paper:

"Our readers, and the whole community, will share with us the poignant regret with which we are compelled to announce the unexpected and untimely death of Dr. Charles Frick, Professor of Materia Medica and Therapeutics in the University of Maryland, and one of our most promising and useful citizens. A malignant disease, contracted but a few days since, in the discharge of his professional duties at the Infirmary, was brought yesterday to a painful and melancholy close, before the tidings of his illness had reached more than a few of the large number by whom he was so justly admired and loved.

"Dr. Frick was a native of Baltimore, a son of the late Hon. William Frick, and at the time of his death had only reached his thirty-seventh year. Enthusiastically devoted to the profession of his choice, he had dedicated to its energetic pursuit all the faculties of an acute and admirable intellect, and had already attained a position in its ranks to which his election to the Chair he occupied was no more than a befitting testimonial. It is for those more familiar with the course of his varied scientific inquiries to render to his professional reputation the discriminating justice which, in so brief a notice as this, it would be wholly inappropriate to attempt. To the public at large he was known as a diligent and faithful student of books and of nature—an independent and original thinker, of large and careful observation and patient and laborious analysis. His contributions to medical literature were frequent and highly esteemed, and through them he was known most favorably to the Faculty, in Europe as well as his own country. In the practical department of his profession, he was eminently popular and successful, not less from the ability and conscientious care with which he fulfilled its laborious duties, than from his cordial and attractive manners and sympathizing nature. In the relations of private life no man ever gathered round him more unqualified affection and respect. He was full of gentleness and kindness, of modesty and unobtrusive charity. As was his work, so be his reward!"

Specialties in Medicine and the Paris Faculty.—Early in last year the Minister of Public Instruction addressed the following question to the Paris Faculty of Medicine: "Are the various branches of Medical Science sufficiently represented in the teaching of the Faculty?" This query was evidently but a polite mode employed by the Minister of acquainting the Faculty with his opinion of the insufficiency of its instruction, as also with the liberality of his disposition to provide the means for rendering it complete. He, however, had the courtesy to leave to the Faculty the merit and honor of taking the initiative in the matter. At the end of three months the Faculty replied to his generous provocation, with the following resolution, carried by a large majority: "That the creation of chairs for specialties would be a very disastrous measure, which would alter the proper character of education, and would prove of no utility for the practical instruction of the student." M. Latour, in the *Union Médicale*, observes: "We hope that the liberal intentions of the Minister will not be discouraged by the resistance of the Faculty. History teaches us with what difficulty corporations accept any innovation which disturbs their quietude. It is not a century since the old Paris Faculty would have felt itself dishonored in seeing any of its chairs bestowed upon the surgeons. They now occupy nearly one-half of these. The spirit of progress has dissipated all these contemptible vanities. Let us still trust to it." M. Diday, of Lyons, has published an eloquent protest against the decision of the Paris Faculty, maintaining that it is the duty of the Faculty to furnish a complete course of instruction to its students, which at the present time it does not do. He maintains that specialties have been the source and cause of the greatest scientific advances, and that the very men who are so jealous of allowing them to be taught are only too happy to call in their aid in the difficulties of practice. Even as it is now, the official teaching is much concerned with specialties. Surgery, taken upon its whole, is but a specialty; Operative Surgery is but a specialty of a specialty; and obstetrics, hygiene, legal medicine, pharmacology, materia medica, &c., are one and all but specialties. M. Diday insists, at great length, upon the absolute necessity of founding two new specialties in the Paris Faculty, that of Psychiâtrie and of Syphiliographie.—*Medical Times and Gazette.*

Suicide in Sweden.—Professor Berg, of Stockholm, has recently published a report on the suicides which occurred in Sweden during the years 1843–51. They amounted to 1,308—*i. e.*, a yearly average of 145·3. A steady increase in their number has taken place since the year 1770. From 1771 to 1775 one suicide occurred amidst 65,320 inhabitants. During the first five years of the present century the proportion rose to 1 in 30,010; from 1816 to 1820, to 1 in 20,690; and from 1816 to 1850, to 1 in 14,830. In the towns the proportion is nearly three times as great as in the country districts. In Stockholm, between 1836–40, there was 1 suicide in every 5,560 inhabitants; and from 1846 to 1850, 1 in 5,390. Of 6,348 suicides occurring since 1816, 5,061 (or 79·72 per cent.) belonged to the male,

and 1,287 (20·28 per cent.) to the female sex. It was seldomest committed by unmarried females, and most frequently by married men. The majority of suicides were committed between the ages of 25 and 50—viz, almost three times as many as before 25, and one-half more than after 50. By far the greatest number occurred in May, viz., more than 14 per cent.; December, November, and February furnishing the fewest numbers: 21·6 occurred in winter, 32·9 in spring, 25·9 in summer, and 20·3 in autumn. As to the form of death, hanging was resorted to in 38 per cent., and to this succeeded poisoning in 24·8 per cent, drowning in 21·4 per cent, stabbing in 8·8 per cent., and shooting in 7 per cent. In the years 1826–31, the kinds of suicide did not observe this proportion; for of 466 suicides, 126 took place by hanging, 123 by drowning, 103 by poisoning, 66 by shooting, and 48 by stabbing. Arsenic is the usual poison resorted to. Poisoning and drowning are more frequently resorted to by women than men; while shooting, hanging, and stabbing occur oftenest among men. In the various districts of the kingdom, the kinds of suicide vary much; some of these, as poisoning or shooting, being in certain parts quite unknown. Drunkenness has been juridically proved as the cause of suicide in more than 20 per cent. of the cases.—*London Medical Circular.*

— At the meeting of the Academy of Sciences in Paris, on December 26th, 1859, M. Leverrier made the following interesting communication: Dr. Lescarbault, a medical man in busy practice at Orgères, in the department of the Eure-et-Loire, is also a zealous astronomer, and a man who supplies by his ingenuity the deficiency of the means which he possesses for prosecuting his favorite science. In March last, M. Lescarbault observed the passage over the sun's disc of a planet within the orbit of Mercury, and he communicated the fact to M. Leverrier, who had noticed certain perturbations in the motion of Mercury, that, in his opinion, could only be explained by the presence of another planet. This was in September last; and thereupon M. Leverrier visited him, together with M. Vallée, and had been enabled to confirm the title of M. Lescarbault to the discovery. The correctness of the results obtained by him was the more remarkable on account of the paucity of his instruments. On arriving at Orgères, M. Leverrier found a regular observatory, with instruments chiefly contrived by the doctor himself, whose finances were limited. Not having a chronometer, he had made himself a pendulum, striking seconds, by means of an ivory ball and a bit of string. Notwithstanding the clumsiness of his apparatus, the calculations of M. Lescarbault varied less from those of M. Leverrier than those of the most eminent astronomers sometimes do from each other. For want of paper, Dr. Lescarbault had generally written down his observations with charcoal on a deal-board; which, with the doctor's calculations written on it, was presented to the Academy by M. Leverrier.

— Subnitrate of bismuth is, M. Velpeau says, of great service in erythematous affections of the skin; there does not exist a better astringent or resolvent: it is also precious in affections of the conjunctiva, because it does not irritate.

Treatment of Small-Pox by Hydrochloric Acid.—I beg to call the attention of the profession to the great value of hydrochloric acid in both the external and internal treatment of small-pox. It allays the prickling pain so distressing in some cases, reduces the tumefaction, the vesicle maturates earlier, and desquamation takes place sooner, leaving the skin smoother and purer than by any other plan which I have tried. Internally, one drachm of the commercial acid to twelve ounces of water; dose, a tea-spoonful in a glass of water; to be sipped often. Externally, I use it to the face, hands, and feet—the parts which suffer most from irritation; for the face, half a drachm to, say, ten ounces of water: apply with a hair pencil twice or thrice daily, using occasionally the mercurial liniment or cold cream. If the cuticle on the extremities be hard and horny, it may be used stronger. I shall not here enter into an account of its specific action, as I am preparing a paper on its use in various diseases, which, with your kind permission, I shall shortly publish in your valuable journal. The present epidemic of small-pox affords ample scope for its trial, and I am confident that it will be as serviceable in the hands of my professional brethren as in mine.—*Dr. Wm. McDonald, in Lancet.*

Pencils of Tannin in Affections of the Uterus.—This form of application, pointed out by Dr. Becquerel, seems likely to be of service in the treatment of lesions affecting the cavities of the neck and body of the uterus. In particular, in the fungous conditions of their mucous membranes, with consecutive hæmorrhages, the tannin pencils might be advantageously substituted for the intra-uterine injections, which are not always free from danger. Dr. Becquerel's formula is: R.—Tannin, 4 parts; gum tragacanth, 1 part; bread-crumb, q. s. to give the proper consistence. These pencils are 5 millimetres in diameter, and 3 centimetres long. To use them, the neck of the uterus is exposed by means of the speculum; a pencil of tannin is introduced by means of the forceps into the os tincæ, and is then pushed into the uterine cavity, and secured there by means of a plug of lint soaked with concentrated solution of tannin. Once in position, the pencil softens and dissolves, and modifies the tissues with which it is in contact. At the end of twelve hours, the plug of lint is withdrawn by means of a thread attached to it. Every three or four days a new pencil is introduced in the same manner; and after a month of this treatment, the fungous state of the mucous membrane progressively disappears, and the hæmorrhages are arrested.—*Bull. Gén. de Téhrap.* and *Edin. Med. Jour.*

— Dr. Pierce observes that he has seen stramonium ointment, as well as the whole list of preparations used for excoriated nipples, but no one has been so universally followed by good results as that made after the following: Tannic acid, gr. xx.; glycerine; alcohol, ää, ℥j. M.

— In 1838, England, with a population of 15,000,000, consumed 35,000,000 pounds of tea; in 1858, with a population of nearly 18,000,000, about 81,000,000.

— Our associate, *Prof. Austin Flint, Jr.*, has recently been appointed to the Chair of Physiology and Microscopic Anatomy in the New Orleans School of Medicine. The former incumbent of this Chair, Prof. Peniston, has been transferred to the Chair of Anatomy, Prof. Beard resigning it and assuming the duties of the Chair of the Principles of Surgery and Surgical Pathology, while Prof. Choppin takes a new Professorship, to be called the Chair of Clinical and Operative Surgery. Dr. Flint, previous to accepting this position, had resigned his Professorship in the New York Medical College.

To the Medical Students of the United States of America.

I will give a premium of $250 for the Essay which shall be judged the best, by competent judges, on the Anatomy and Physiology of the Animal and Organic Nervous Systems.

The Essays to be sent to me on or before the first of March, 1861.

I will likewise give a second premium of $250 for the best Essay on the same subject.

The Essays to be handed in on or before the first of March, 1862.

The medical students who shall be declared the successful competitors will be required to declare, on their *word* and *honor*, that the Essays are their own productions, and that they have not been assisted by any legally qualified medical man. JOHN O'REILLY, M.D.

230 FOURTH STREET, WASHINGTON SQUARE, SOUTH,
March 8th, 1860.

Books and Pamphlets Received.

A Medico-Legal Treatise on Malpractice and Medical Evidence, comprising the Elements of Medical Jurisprudence. By John J. Elwell, M.D., Member of the Cleveland Bar. New York: John S. Voorhies. 1860.

Lectures on the Diseases of Infancy and Childhood. By Charles West, M.D., &c. Third American, from the Fourth Revised and Enlarged London Edition. Philadelphia: Blanchard & Lea. 1860.

The Diseases of the Ear; their Nature, Diagnosis and Treatment. By Joseph Toynbee, F.R.S., &c., with 100 Engravings on Wood. Philadelphia: Blanchard & Lea. 1860.

Clinical Lectures on Certain Acute Diseases. By Robert Bentley Todd, M.D., F.R.S., &c. Philadelphia: Blanchard & Lea. 1860.

The Action and Sounds of the Heart; a Physiological Essay. By George Britton Halford, M.D., &c. London: John Churchill. 1860.

On the Circulation of the Blood in the Venous System during Life. By George Murray Humphrey, M.D., F.R.S., &c. Cambridge: Macmillan & Co. 1859.

On Excision of the Knee-Joint. By Oliver Pemberton, Surgeon, &c. London: T. Richards. 1859.

THE AMERICAN

MEDICAL MONTHLY.

EXTRA—APRIL, 1860.

The Physiology of the Circulation. A Course of Lectures delivered at the College of Physicians and Surgeons, New York, in the Fall Term of 1859. By JOHN C. DALTON, JR., M.D., Prof. of Physiology and Microscopic Anatomy.

LECTURE I.

(SEPTEMBER 20, 1859.)

Subject of the Course—Nature of Physiological Studies—Relations with Anatomy—Methods of Physiological Investigation—Experiments on the Living Body—Objections to this Method—Their Futility—Difficulties in the Way of Physiological Experiments—Complication of Physiological Phenomena—Their Variability—Influence of External Agents—Of Internal Conditions—Means of avoiding Error from this Source—Special Rules for conducting Physiological Experiments—Variation of Results in different Species of Animals—Difference between Direct and Indirect Results of an Operation—Examples—Individual Peculiarities of different Animals.

GENTLEMEN—The Course of Lectures which we are now about to commence is a Special Course on the Physiology of the Circulation; and I think we shall find that in selecting what might perhaps be regarded as a somewhat limited subject, we do not in reality narrow the field of study which is opened to us, but, on the contrary, enlarge it, for all purposes of real improvement and experimental inquiry. For each special group of the animal functions is found, upon examination, to be vastly richer in its details, and more complicated in its relations, than we should anticipate from a mere cursory inspection; and in confining our attention, for the present, to the phenomena of the Circulation, we shall gain space and time to follow out these phe-

nomena in many important connections, and to study in detail the many varied conditions upon which they depend.

But before commencing the study of the particular facts relating to our present subject, it will be worth while to say a few words on the nature of physiological investigations in general, and on the manner in which they should be pursued. For physiology is a science of such recent growth, and is concerned with phenomena of so peculiar and special a character, that we cannot properly appreciate the value or significance of the facts presented to us, unless we fully understand the manner in which they are discovered, and are familiar with the tests to which they should be subjected.

Physiology, gentlemen, follows in the natural order of study upon Anatomy, with which it always is, and must be, most intimately associated. No one can examine the situation, size, and shape of an internal organ, without asking himself, at least, what are its functions, what purpose does it serve in the animal economy, and what are its relations to the neighboring parts. Anatomical facts, by themselves, would be destitute of interest, unless they were connected in some way with physiological actions. On the other hand, it is evident that we cannot advance a single step in physiology without the aid of anatomical facts to rest upon. Not only must we know the locality, form, and texture of the principal organ before we can study its actions, but there are a thousand anatomical details, which are requisite to enable us to perform our experiments, or even to make the commonest physiological observation, without danger of misinterpreting its results. How essential is it, for one who is investigating the physiology of the chyle and lymph, to know all the divisions and inosculations, both constant and occasional, which exist between the different parts of the lymphatic system, or between the lymphatics and the veins! Such an anatomical relation, if unknown or neglected, might entirely vitiate the result of an otherwise well-contrived and faithfully-executed experiment. The experiment of tying the pancreatic duct, for example, was supposed to prove the secretion of this gland to be unnecessary for the digestion of fatty substances in the intestine, until it was discovered that the pancreas has habitually two ducts instead of one, and that its secretion may therefore find its way into the intestine by the second of these ducts, after the first has been obliterated. The knowledge of anatomical details is accordingly essential to the physiologist. They are the necessary tools, without which he cannot do his work thoroughly, nor engage safely in any experimental investigation.

It is natural, therefore, that the study of anatomy should have preceded, in the order of time, that of physiology. The former was already far advanced, as a science, before the latter had begun to be successfully cultivated; and the study of the one seems naturally to open the door for that of the other. It is on this account that the connection between the two has sometimes been supposed to be more intimate than it is in reality. Anatomy is sometimes regarded, not only as a necessary assistance to the study of physiology, but as actually furnishing the data from which physiological truths may be derived, as consequences or corollaries; particularly when the study of microscopic anatomy first began to be successfully cultivated, it was thought that such thorough and detailed acquaintance with the minute structure of the organs would necessarily give us a more complete insight into their functions. Every variety of physiological action was regarded as necessarily connected with a special arrangement of the anatomical elements; and it was expected that the peculiar function of an organ or tissue would easily be detected, as soon as we had mastered all the details of its anatomical structure, and had learned the exact distribution of its fibres, its cells, its blood-vessels, and its nerves.

It is necessary, however, that we should understand in the outset, if we are to pursue with success any department of physiology, that we cannot rely upon such methods of investigation. There is no such connection between the structure of an organ and its function, as will enable us to deduce the one from the other. However minute the structure, and however simple the function, the latter is always to be ascertained by separate and direct experiment, and in no other way. A knowledge of structure, therefore, enables us to perform the experiment, but not to foresee its result. The connection between the structure and function, when this connection exists, is usually of such a nature that we cannot understand it, even after we know both the anatomy and physiology of an organ; much less anticipate it beforehand. The physiological action of a part is accordingly, in most instances, a vital property, the existence of which cannot be explained from anatomical facts, but can only be established and demonstrated by direct experiment.

Here, for example, is one of the principal cranial nerves, (third division of the Fifth Pair,) which has been dissected so as to exhibit the course of its different branches. The nerve emerges, as you see, from the foramen ovale at the base of the skull; and one of its branches, after supplying the tongue and the parotid gland, passes

forward, through the dental canal, in the inferior maxilla, to the region of the chin and lower lip; while the other breaks up into ramifications which are distributed to the muscles moving the lower jaw. Now, there is no difference in the external aspect of these two branches; and if we examine them by the microscope, we shall find them both composed of nervous filaments having the same size, the same structure, the same arrangement. To all appearance the anatomical constitution of the two branches is the same; and yet their physiological properties are totally distinct, for experiment shows one of them to be motor, and the other sensitive.

We cannot even rely upon the ultimate distribution of the nerves, in order to decide whether they are sensitive or motor, since the muscles also receive sensitive filaments to which they owe their sensibility, as well as motor filaments which give them the property of contraction. The superior laryngeal nerve, for example, sends a branch which is distributed to the arytenoideus muscle; but this branch is nevertheless sensitive and not motor, for experiment shows that its division neither paralyzes the muscle to which it passes, nor does its excitement by galvanism produce any convulsive action in the same part.

Here are two glandular organs, the parotid and the pancreas. Both have the same firm consistency, whitish color, and lobulated texture. They are both composed of similar rounded follicles, lined with glandular cells, and opening into tubular excretory ducts. They are so much alike that, among the Germans, the pancreas has been named after the parotid, and called the "abdominal salivary gland," *(Bauch-speichel-drüse.)* Both of these organs, furthermore, are supplied with the same arterial blood; and yet one of them secretes saliva, a thin, watery fluid, containing less than two parts per thousand of organic matter; while the other produces the pancreatic juice, a viscid secretion, containing ninety parts per thousand of organic matter, and quite different in its physiological properties from any other glandular fluid.

Even where a difference in anatomical structure exists between two organs, there is often no necessary connection to be detected between this difference of structure and the peculiarities of their physiological action. The voluntary muscles, for example, are composed of large, cylindrical, striated muscular fibres, the contraction of which is sudden, easily excited, and instantaneous in duration; while the involuntary muscular fibres are small, flattened, fusiform and ribbon-shaped, and, at the same time, sluggish in contraction. But a knowledge of

the anatomical characters of these two fibres would never be sufficient to teach us the nature of their physiological peculiarities. The difference between them can only be learned from experiment and observation.

We find, therefore, that anatomy is subservient to physiology only as a means of study. Physiology, as a practical pursuit, rests upon a different basis, and is to be carried on by other methods, since it leads our investigations into another domain, and carries them far beyond the limits which confine the labors of the anatomist. He is interested, as an anatomist, only in the size, the location, the form, and the structure of the different parts of the body. He enumerates the processes and foramina of the bones, the attachment of tendons and ligaments, and the distribution of blood-vessels and nerves. These details are, all of them, important, and possess a certain amount of scientific as well as practical interest; but they can never, of themselves, satisfy him who has once commenced the study of the animal frame, whatever may have been his primary object. The vital activity of these different parts, and their physiological relations with each other, soon become infinitely more important, in a scientific point of view, than the mere particulars of form and structure. What should we think of a naturalist whose whole interest was absorbed in the dry bones and the stuffed specimens of a zoological museum, but who could give no account of the history, action, and habits of the animals during life? Such is the position of the student who has mastered the details of anatomy, but has not used this knowledge as a means of introduction to physiology.

The naturalist, who comprehends his subject, goes much further than this. The great Audubon, in preparing his masterly work on the Birds of America, did not pursue his labors alone in the library and the dissecting-room. He penetrated into the forests and the mountains, and, concealed in swamps and thickets, lay patiently in wait to watch the movements of the birds, and to study their peculiar habits and their modes of life.

We, then, gentlemen, as physiologists, are the naturalists of the living body. Our object is to study its movements, to learn its habits and functions. Our business is to penetrate into the recesses of the internal organs, and to lie in wait, so to speak, to watch their complicated processes, and to learn the secrets of their physiological action. For the anatomist, the body is to be examined as an inert and lifeless frame, composed of bones, muscles, ligaments, and membranes, with the fluids contained in their appropriate cavities and tubes. But

for us, it is an animated and active organism, with the muscles alternately contracting and relaxing, the lungs inhaling and exhaling the atmosphere, the heart beating, the fluids circulating incessantly from one extremity to the other, and every fibre palpitating with life and sensibility. Such is the field presented to the study of the physiologist. It is easy to understand that this is a very different subject, both in its nature and its mode of study, from that which engages the attention of the anatomist. It is the difference between life and death, between force and inertia, between repose and activity.

From what I have just said, we can readily comprehend what are the appropriate methods for pursuing the study of physiology. It is only by experiment and observation upon the living body, that we can learn what are the actions and processes which go on in it during life. Simple observation, indeed, will teach us but little. Most of the organs are concealed in the interior of the body; and we must, accordingly, resort to experiment in order to discover their functions. Even for the most palpable and external of the vital phenomena, as, for example, the inspiration and exhalation of gaseous matters by the breath, some artificial contrivance is usually necessary in order to secure accuracy in the results of observation. It is, therefore, by experiment upon the animal frame and its immediate products that we mainly succeed in the acquisition of physiological knowledge.

It is true that there are many other modes of experiment which will assist us more or less in our study of the vital actions. Certain physical and chemical investigations are often of service, by leading us into the right path, and by indicating the direction in which our purely physiological examinations are to be pursued. Analogical surmises, and inferences from what we know of other phenomena, may also aid us in reaching the solution of the doubtful question which is to be decided. But in all these cases the physical or chemical knowledge which we obtain, or the scientific analogies which may be presented to us, can only be useful so far as they may suggest probabilities, and thus direct our researches in the proper channel. In every instance the decisive experiment must be one which is concerned only with the animal organism. We may experiment, for example, upon endosmosis and exosmosis, with cups and bladders in the laboratory, and may gain, in this way, a certain amount of knowledge as to the nature and operation of these forces; but it is impossible to ascertain the manner in which they actually take place in the interior of the body, or to measure the processes of exudation and absorption of the

animal fluids in the course of the circulation, except by experiment upon the living body itself.

If we were to depend upon any other mode of investigation than that which I have just mentioned, for the definite solution of physiological questions, we should be constantly liable to erroneous conclusions. In all preliminary investigations it is our object to make the conditions of the experiment as similar as possible to those which exist in nature; and the more nearly these conditions resemble each other, the more valuable will be the result. But they can never be made absolutely identical; and the result will, accordingly, be more or less doubtful so long as the conditions of the experiment are in any degree artificial.

For it must not be forgotten that the object of all our researches is to become acquainted with the physiological phenomena, *as they actually take place in the living body;* and direct examination shows that these phenomena, even when of a physical or chemical nature, are often quite different from what we should expect from our general knowledge of chemistry and physics, or from the results of previous physical and chemical experiments.

Here, for example, is a thin solution of hydrated starch, into which I pour a few drops of iodine water. The mixture, you observe, instantly assumes a deep, opaque, blue color, which is characteristic of the reaction of these two substances. Here, on the other hand, is a small quantity of an animal fluid, viz., freshly secreted saliva. If we now, instead of mingling the starch and iodine by themselves, mix them in the test-tube containing the saliva, no reaction takes place between them, and no blue color is produced. We can even, as you see, destroy the blue color already produced by the mixture of starch and iodine, by adding to it an equal quantity of saliva.

The chemical reaction, therefore, does not take place in the presence of the animal fluid, as it would do under ordinary circumstances.

Here is a little distilled water, to which I add a drop or two of honey. I then put into the solution a little sulphate of copper, and afterwards some caustic potass, both dissolved in water. The mixture now takes a clear blue tinge, owing to the presence of the sulphate of copper. On boiling the mixture, it rapidly becomes turbid and yellow, and is soon filled with an abundant, bright, yellowish-red deposit of the suboxide of copper. This is Trommer's test for grape-sugar, and is one of the most convenient and certain means of detecting that substance when in a state of purity.

Here, however, is some gastric juice from the dog. I put into it a

drop or two of honey, and thoroughly mix the two fluids together. I then add sulphate of copper and caustic potass, for Trommer's test, as before. The mixture, you see, instead of a blue color, has now a bright purple or violet tinge; and on boiling it, though it loses the purple color and becomes yellowish, no deposit is thrown down, and the fluid remains simply opalescent. In these cases, the usual action of the chemical tests has been altered, on account of a peculiar organic matter existing in the animal fluids, which has its own special properties and reactions, and interferes, accordingly, with the action of other substances which may be present.

It is for a similar reason that the action of drugs upon the living body can never be anticipated with certainty from a knowledge of their ordinary chemical properties; and therapeutical systems based upon such purely chemical data are usually found, in practice, to be erroneous, because some unforeseen peculiarity of action almost always intervenes, in the interior of the body, to disturb our calculations. Accordingly, we can seldom determine what changes a drug will undergo on being introduced into the system, except by actually searching for it in the blood and secretions. If iodine, for example, be taken internally, it is discharged from the body with the secreted and excreted fluids—saliva, perspiration, urine—but never in a free state. It always enters into an intimate organic combination in the animal fluids, and accordingly cannot be detected, either in the blood or the secretions, by the test of starch, unless the organic matter with which it is in union be first destroyed by the addition of an acid. The precaution, therefore, which has been sometimes inculcated, of forbidding to patients the use of bread, or other starchy food, for an hour or two after taking iodine, is entirely unnecessary; for we find that iodine will not combine with starch in presence of an animal fluid, but unites, in preference, with the organic matter which is in solution.

The malates, citrates, and tartrates, again, of soda and potass, when taken into the system, do not appear under their own form in the secretions; but the organic acids of these salts are replaced, during their passage through the circulation, by carbonic acid, and they are, accordingly, discharged, in the excreted fluids, as the carbonates of the same bases.

It is by experimenting, therefore, upon the living body that we shall endeavor to gain an insight into its physiological operations. That is the only source from which we can derive absolute and positive information, and it is to that test that all unsettled physiological doctrines must finally be submitted.

I wish, however, for the time which remains to us in this lecture, to examine, in the first place, certain objections which have been made against experimenting upon the living animal; and, secondly, to enumerate the more important difficulties which lie in the way of this mode of investigation, and the precautions which are necessary to insure its ultimate success.

And, first, as to the objections urged against it.

I would say, however, to begin with, that whatever these objections may be, it is certain that they cannot destroy the comparative value of this mode of study; since, however deficient a method this one may turn out to be, it is evident that *there is no other upon which we can rely.* This follows from what we have already said as to the nature of the vital functions, and the manner in which they are naturally performed. There is no alternative left us, therefore, if we wish to study physiology, of choosing this course or another, for this is the only mode by which we can hope to obtain the desired information. There is no other way of learning the operation of physiological phenomena than by seeing how they actually take place in the organism itself. It is only in the liver that we can investigate the formation of the bile, and only in the intestine that we can follow the changes of its decomposition; and we might as well try to find the Northwest Passage by exploring the Southern Ocean, as to study the phenomena of the circulation *anywhere* but in the blood-vessels of the living body.

The objections to this method have originated, however, as I think, for the most part, in an undue estimate of other means of study, rather than in positive experience of its own want of value. Experimental physiology is, by some, underrated and neglected—not because it has been tested and found wanting, but because it is easier to construct a "physiology of probabilities" out of such materials as Analogy, and what is called the "Unity of Scientific Truth." That, however, is not the kind of physiology which we propose to study; and, accordingly, these methods of inquiry are not the ones adapted for our employment.

The principal difficulty which has been directly urged in regard to the method of experimentation upon the living body is, that there is danger of fallacy in such investigations. The objection has been expressed as follows: "Nature tortured," it is said, "does not tell the truth by any means as clearly as nature with its ordinary relations." It is not meant by this that the pain which the animals suffer, while being experimented on, produces false appearances, and so deceives the experimenter. It is very rarely necessary to inflict pain for purposes of physiological experiment. The employment of ether and chloroform,

which are fully as useful to the physiologist as to the surgeon, enables us to do the requisite preliminary operations without the animal's experiencing any sense of suffering, and even without his consciousness. It is only certain experiments upon the nervous system which cannot be done without inflicting pain upon the animal; but in these instances the existence, or otherwise, of a painful sensation is the special object of the experimenter's research; and its indications, accordingly, so far from being liable to mislead him, or to vitiate his results, are the very means upon which he depends to arrive at a correct conclusion.

The real meaning of the above-mentioned objection, as it is usually understood, is, that the necessary steps of the preliminary operation, the incisions, ligatures, mutilations, &c., interfere with the usual action of the animal organs, and introduce a disturbing influence into the play of the vital functions; and that nature is thereby "tortured," or distorted, to such an extent that the experimenter is liable to meet with false and uncertain phenomena, and to derive from them erroneous conclusions.

This objection, however, is one which certainly would never be made by a practical experimenter, for the reason that the difficulty to which it refers is always present to his mind, and is one against which he is constantly guarding by unremitting precautions. This, in fact, is the very first and simplest lesson which is learned by the experimental physiologist. You might as well object to the researches of an astronomer, that the refractive power of the atmosphere distorts the rays of light passing through it, and thus falsifies the appearances presented by the telescope, and vitiates the conclusions of the observer. The astronomer is perfectly familiar with this refractive power of the atmosphere. He knows the mode of its operation, and makes allowance for it in all his calculations. So the physiological experimenter, in prosecuting his observations on the living body, sees at once that the external agents which he employs in his operations, and the manipulations to which he is compelled to resort, themselves exert a certain amount of influence in producing the final result. It is always his object, in contriving an experiment, to reduce these disturbing influences to the smallest possible compass and the simplest possible form. It is frequently necessary to vary the method of procedure, for the same experiment, in order to determine how much, if any, of the result finally produced is attributable to the principal conditions, and how much to the accessory manipulations. Abundant instances of this are to be found in the history of investigation upon almost every physiologi-

cal question; and it would be a bungling experimenter, indeed, who left out of consideration the physical conditions which he himself had employed in operating upon the living body.

I have already stated, gentlemen, that we cannot depend, in studying physiology, upon the examination of external phenomena, and that we must finally resort to experiment upon the animal organism itself; and I also mentioned that the principal reason for this necessity was, that we could never reproduce externally the exact natural conditions which are present in the living body. It follows, therefore, that our first care, in experimenting, should be to alter these natural conditions as little as possible, in order that the physiological phenomena themselves may be undisturbed. Is one of the internal organs to be reached and examined by the experimenter? The opening in the abdominal walls should be of small extent, and made without exposing or injuring the neighboring parts. Is a specimen of blood to be withdrawn from a particular vein, for purposes of comparative analysis? The vein upon which we are to operate should be exposed carefully and rapidly, the ligatures applied before the natural course of the circulation is disturbed, the blood withdrawn just as it comes fresh from the capillary vessels, and collected in such a way as not to allow of the admixture of any other of the circulating fluids. Of course, the conditions of our experiment can never be precisely those which exist in the ordinary state. It is because the vital operations of the body are naturally concealed from observation that we are obliged to resort to experimental contrivances in order to gain some knowledge in regard to them. But with proper care and judgment in their employment, these contrivances need not interfere with the principal phenomenon which is to be observed. Our experiments can never, it is true, present us with a complete panorama of the animal functions in the uninterrupted harmony of their actual operation; but they may enable us, by separate observations and the study of isolated phenomena, to comprehend the mode in which all the organs act together, in their natural and undisturbed condition.

There are, however, other and more serious difficulties in the way of physiological investigation, and certain precautions which are indispensable for the practical experimenter, besides those already mentioned.

I. In the first place, the principal peculiarity which distinguishes the phenomena of organic life is, that they are complicated. The result of a physiological experiment is often not a direct and simple one, as in the case of physical or chemical investigations, but depends upon the combined operation of various forces, each of which exerts its own

share of influence. The same phenomenon, therefore, is susceptible of different interpretations, until we have finally mastered all the elements which are concerned in its production. If the pneumogastric nerve be divided, for example, in the dog, in the middle of the neck, respiration soon becomes diminished in rapidity. At the end of a few days the animal dies, and the lungs are found in a peculiar state of engorgement and solidification, impermeable to the air, and evidently incapable of performing their functions. Coagula are also frequently found in the cavities of the heart and the pulmonary vessels, sufficient to interfere with the natural course of the circulation. But we should be mistaken if we supposed that the division of the nervous filaments distributed to the lungs was the direct cause, either of the engorgement of the pulmonary tissues, or of the coagulation of the blood in the pulmonary vessels. For the pneumogastric nerve is also distributed to various other organs, and the interruption of its influence over them disturbs indirectly the functions and nutrition of the lungs. The muscles of the larynx, in particular, are supplied by the recurrent laryngeal nerve, a branch which leaves the pneumogastric at the lower part of the neck. A paralysis of these muscles stops the regular movements of the glottis, by which it usually expands at the time of inspiration and collapses during expiration, and the air accordingly no longer finds a free access to the trachea and lungs; the pulmonary circulation consequently becomes sluggish, the blood coagulates in the vessels, and the pulmonary tissue becomes engorged and solidified. The substance of the lungs, therefore, is altered, not because its own nerve has been cut off, but because the branch distributed to the larynx has been divided at the same time. The proof of this is, that if the recurrent laryngeal nerve be divided on both sides without injuring the main trunk of the pneumogastric, the lungs after a time present the same kind of engorgement and solidification as in the former instance.

If a dog be fed with a mixture of meat and boiled starch, we know that the starch is rapidly converted into sugar; for the sugar may be found, if sought for at the proper time, in the duodenum of the animal, where the intestinal fluids act upon the food, and transform its starchy ingredients. But if the examination be delayed a little too long, no sugar will be discovered; because, simultaneously with the digestion of the food, the process of absorption is going on in the intestine, and the saccharine material which is produced is rapidly removed and carried into the circulation. There are many instances in which, by these compound processes of secretion and absorption, of production and

decomposition, effects are produced which could not be obtained from either of them alone.

II. In the second place, the vital phenomena are variable at different times. The living body is not an inert structure composed of unchangeable materials. It is an active and impressible organization, susceptible to the influence of external causes, and subject even to variations of an internal and periodical nature. It is on this account that the physiologist, in commencing his practical investigations, finds it so difficult to foresee the result of an experiment from one trial to another. An experiment which succeeds to-day will fail to-morrow, though repeated with the same care and observed with the same fidelity. This is because some unforeseen circumstance has arisen, which, though apparently too trivial to attract the attention of the observer, is yet sufficient to influence the animal organism or its products, and so alter the phenomena which they present.

I need not impress it on you, therefore, that in physiological experiments, more than in any other, it is of the first importance that the surrounding conditions should be always absolutely identical. The quantity of material used, the quality of the instruments, the time and order in which the different steps of the operation are performed, must all be arranged with precision; for any of these circumstances are liable to influence the result. I have here a bottle of venous blood from the ox. I pour some of it into another empty bottle; and, on shaking it up with atmospheric air, you see the dark blood immediately assume a bright vermilion tinge, just as it does in the capillaries of the lungs. Here is another bottle of venous blood, of similar appearance, from the same animal. On shaking it up with air as before, the color, you see, suffers but little perceptible change, but remains nearly as dark and venous as before; and yet these two specimens of blood were both taken from the same animal, drawn in the same way, and treated with the same agents. The only difference is, that the second specimen has been withdrawn from the vessels from thirty-six to forty-eight hours longer than the first. During this time a change has taken place in its organic ingredients which renders it less susceptible of reddening under the influence of the atmospheric oxygen.

Even where the animal fluid employed is perfectly fresh, a similar variation may be observed in its properties in two different experiments; because the vital condition of the whole body, or of some particular organ, is different on the second occasion from what it was on the first.

A striking example of this is to be seen in the secretion of the saliva,

and its power of converting starch into sugar. All physiologists are now agreed that the saliva taken from the cavity of the mouth is capable of converting boiled starch into sugar; and yet the intensity of this action varies in a manner which has been hitherto altogether unexplained. At one time it requires ten or fifteen minutes to show traces of sugar in the mixture of starch and saliva, and at another, the sugar can be detected readily, by the ordinary chemical tests, at the end of half a minute. This is because some organic ingredient of the saliva, essential to its action on starch, is more readily secreted at some times than others; but we have not yet succeeded in ascertaining why or when the variation takes place. Practically, in preparing for an experiment of this nature, we must always test beforehand the particular specimen of saliva which we are to use; for, otherwise, we can never be sure that its activity is the same with that which was secreted a day, or even a few hours, before.

But there are many instances in which we know upon what particular circumstances such variations in the vital phenomena are dependent. They are frequently owing to a difference in the size, age, sex, vigor, constitution, &c., of the animals employed for experiment. Age alone will sometimes have such an effect as to alter entirely the effect of certain injuries or operations. I have already mentioned that if the pneumogastric nerves be divided in an adult dog, the respiration becomes diminished in rapidity, and death comes on gradually at the end of from three to six days. But if the same operation be done upon pups but a few days old, a violent choking at once occurs, owing to a more complete closure of the glottis; and death supervenes very rapidly. Legallois has even seen a young dog, under these circumstances, die instantaneously from suffocation—an accident which never happens with the adult animal, since, in him, the orifice of the glottis is only diminished in size by paralysis of the laryngeal muscles, and not completely obstructed.

Among the most important of these variations are those which depend upon periodical changes in the vital functions, recurring, perhaps, at intervals of a day, or even a few hours. An experiment may have different results in two animals, precisely similar in their external appearance, because their internal condition is not the same in reference to the alternations of waking and rest, of fasting and digestion. Here are two specimens of blood, both drawn yesterday from the vessels of the dog. In both coagulation has taken place, and in both the clot and serum have separated from each other. But in one, you see, the serum is of a clear amber color, perfectly homogeneous throughout. In

the other, the surface of the serum is covered with a white, milky film, which is composed of minute fatty granules and molecules in a state of emulsion. This peculiar appearance is due to the blood having been drawn during the digestion of food containing fatty ingredients. A few hours later it would have entirely disappeared, and the two specimens of blood would then be alike.

Enough has been said, therefore, to show why physiological experiment has been sometimes thought subject to deception, and unreliable, and to show, also, how erroneous in reality such a conclusion would be. The vital phenomena of the living body, in point of fact, are not in themselves variable, any more than other natural phenomena; they are only dependent on a greater variety of surrounding conditions. The result of a physiological experiment will always be the same, provided the conditions under which it is tried be also identical. If, therefore, we find that an experiment which succeeded yesterday fails to-day, or has a different result, we shall always discover, on examination, that there is some difference in the mode of its performance, which causes the variation. There are no contradictions in nature, but only in our imperfect observation or interpretation of the natural phenomena. So far from being confused or disappointed, therefore, by such an apparent contradiction, we should simply set ourselves at work to discover the cause upon which it depends; and, when this is accomplished, the certainty and extent of our knowledge will be increased, instead of diminished.

III. It follows from what has been said, in the third place, that the apparent contradictions of physiological experiment, instead of destroying the value of its results, may in reality serve to enhance the accuracy of our knowledge, and to open to the inquirer new paths of investigation. It is, accordingly, a most injudicious thing for the experimenter to neglect or throw aside any phenomena which he may notice, because they appear to be in opposition with others which he has already observed. The apparent opposition between the two is of itself an important fact, which may turn out, if properly investigated, to be fruitful in new discoveries. Suppose, then, that we have observed certain results to take place in a series of experiments, and have deduced from them certain conclusions. A year afterwards, on repeating the trial, we meet with results which are not in accordance with the previous ones. Are we, in this case, to neglect the phenomena which we have observed last, and adhere to our old opinion? Or are we to suppose that there was some mistake about the former experiment, and continue to reason from our present results as if we had

never met with any other? There are persons who would adopt one or the other of these alternatives, according to the character of their mental constitution, or the nature of the facts in dispute. But either method would be wrong, for they are both based on a mistaken principle. To neglect a fact actually observed, is as much a falsehood in science as to imagine one that has never been seen. Neither the new nor the old observation, accordingly, is to be disregarded, but equal value should be given to both. The one does not invalidate the other; and we know that further investigation will certainly reconcile the apparent discrepancy.

I need not remark, however, that in order to depend thus implicitly upon his experiments, the physiologist must be habituated to observe every phenomenon, precisely as it occurs, without reference to anything else than the simple result of the experiment. Without such precision in the observation of details, the experiment will often be worthless; and particularly if the experimenter be unduly influenced by the supposed explanation which he desires to give of the phenomena in question, he may allow certain appearances to escape his notice or his memory, which are essential parts of the entire experiment. Subsequently, then, he may be puzzled by meeting with contrary appearances, when, in reality, the results of both experiments are essentially the same, and would not even appear to be different if he had not neglected or forgotten some of the details in the former instance.

In experimenting with animals, accordingly, we must first keep in mind the complicated nature of the phenomena which they present. We must remember, especially, that the *result* of an experiment is one thing, and our *interpretation* of it another. Our interpretations may afterwards turn out to be erroneous, or require to be modified, but the physiological phenomena are the same, and are not affected in any way by the alteration in our mode of explaining them. When our theories, accordingly, are changed with the progress of time, we do not lose anything in giving up the old ones for the new, because we do not sacrifice any one fact, however insignificant, which has ever been observed. We only change the hypothetical arrangement in which we had placed these facts, and enlarge it so as to include others equally valuable.

The physiologist, therefore, must never allow himself to regard these theoretical explanations as of more value than the actual phenomena which he sees to take place in the course of experiment. Whenever we observe any natural events or appearances, the constitution of our minds leads us at once to endeavor to reduce these appearances to

some regular arrangement or order, and so subject them to the expression of some general law. But we must never regard these hypothetical laws as equal in importance to the phenomena which present themselves in nature. Any fact or event, actually observed, is superior in value to any theory or law ever framed in scientific language; for these latter are altogether ideal and temporary in their existence, while the phenomena to which they relate are positive, absolute, and imperishable. No doubt there are in nature certain laws or principles which are invariable, and to which the operation of all phenomena is subjected; but our only hope of learning what these laws really are, is in questioning nature herself by experiment, and relying implicitly on the answers which we receive. For the phenomena actually witnessed are the only real expression of the laws which regulate them; and any law which is not in accordance with every phenomenon that may be presented, is, *ipso facto*, false, and does not represent the real principle which exists in nature, and which it is our object to discover.

In practice, then, we must be ready to receive every appearance that may be presented during an experiment as equally absolute and valuable, whether it corresponds with our previous ideas, or whether it leads us in a new direction and suggests the adoption of a more comprehensive theory. It is only when the mind of the observer has arrived at this condition that he is secure from self-deception, and that he is always certain of making progress, whatever may be the appearances which he meets with.

IV. Fourthly, there are certain rules, also, of a special nature, very important for the practical physiologist. One of these is, that the same animal should never be used for more than a single experiment, nor the same experiment employed to demonstrate more than a single point. The principal reason for this is evident; for if the animal have already been subjected to an operation which disturbs the action of a single organ, we cannot depend upon the action of others, which may be affected by sympathy with the first. Every experiment, to be reliable, must be tried upon an animal in the uniform and standard condition of perfect health. If the pneumogastric nerve of a dog have been divided, we cannot safely make use of him for an experiment upon the saliva; for though there is no direct connection between this nerve and the parotid gland, the secretion may suffer from the indirect influence of the heart or the stomach. But besides this, there is another reason for the above rule, which relates more to the experimenter than to the animal upon which he operates. It is this. In an experiment, the mind of the observer always is, or should be, intent upon a single

point. He wishes to ascertain positively and distinctly the action of a bodily organ under certain conditions, and he makes all his arrangements to secure accuracy and success in observing its details. Now, if he endeavors, at the same time, to use this opportunity for noticing other phenomena of a different nature, and disconnected with the first, he will find that his mind is not in a condition to appreciate both sets of appearances in a proper manner. Either, in taking care not to neglect the first part of the experiment, he will observe the second loosely and carelessly; or, in paying attention to both, he will find that neither of them have been conducted with sufficient accuracy to make them reliable. Besides, in most experiments upon living animals, a certain order and celerity in the mechanical manipulations are requisite to insure success; and if we try, at the same time, to introduce other contrivances, however simple, the chances are very great that they will interfere, just at the wrong moment, with some necessary part of the principal operation, and all the labor of the experimenter will be thrown away. Each experiment, then, should be contrived and executed by itself. This seems to involve a great expense of time and material. But if we try to economize by making one operation answer for two experiments, or by making one experiment settle two questions, we shall find that, instead of saving, we have lost. "One thing at a time" is nowhere a more necessary rule than in physiological experiment; for in that, to do one thing only requires so many carefully-arranged accessories that it will not bear to be encumbered with further complications.

V. Fifthly, there is a certain caution always to be observed in comparing the results of experiment upon different species of animals, since experience shows that these results are often not the same; for nearly all kinds of animals have certain peculiarities of function which distinguish them from other species, however nearly related. They are peculiar in their mode of life, in the mechanism of their digestion or circulation, or in the excitability of certain organs or tissues. Even the constitution of the animal fluids, though presenting a general resemblance among all the quadrupeds, and even all the vertebrate animals, presents specific differences in particular instances. Thus, the urine contains, as its characteristic ingredients, urea and alkaline urates in man and the carnivorous animals, urea and alkaline hippurates in oxen and horses, and salts of uric acid, without urea, in birds and reptiles. The peculiar ingredients of the bile are so similar in all animals in which it has yet been examined, that they may be detected by the same test, (Pettenkofer's test;) and yet they are specifi-

cally distinct in man, in the ox, the dog, the cat, the pig, &c., and may be distinguished by special reactions.

All these peculiarities are to be borne in mind when we apply the result of one experiment to another species of animal, or the result of experiments on animals to the human species. On examining the nature of this dissimilarity and resemblance which exist at the same time between different kinds of animals, we shall see how far the resemblance between them may be trusted, and why, in certain cases, a comparison will not hold good.

I have already called your attention to the fact that physiological phenomena are complicated in their nature, and that the results of physiological experiment are liable to be complicated in the same degree. In fact, nearly every experiment or operation upon the living body has two different results, viz., a *direct* result and an *indirect* result; the direct result being due immediately to the effect of the operation upon the particular organ interested, and to nothing else; and the indirect result following, in a secondary manner, upon the disturbance caused among several contiguous organs, and to the reaction between them. Thus the direct effect of division of the spinal cord is loss of voluntary motion and sensibility in the parts below; its indirect effects are retention of the urine from paralysis of the bladder, decomposition of the urea into carbonate of ammonia, an irritating condition of the excreted fluid, and inflammation of the urinary passages. Now, it is found that in all vertebrate animals the general plan of structure and function is so similar that the *direct* effect of an experimental operation is always the same, or varies only in rapidity, intensity, and duration. Thus in all animals the anterior roots of the spinal nerves are found to be motor in their function, and the posterior roots sensitive. In all, the lungs absorb oxygen and exhale carbonic acid. In all, an acid gastric juice is secreted by the stomach on the entrance of food, which it disintegrates and liquefies by a process of chemical solution and transformation.

We find, however, that there is often a great difference in the rapidity with which certain effects are produced. Thus, in all animals a complete stoppage of respiration produces death; but in birds and quadrupeds the fatal effect follows in a few moments, while in most reptiles death is not produced in less than from half an hour to an hour. Dogs, if kept at rest and prevented from running about, may be entirely deprived of food for eight or ten days without exhibiting any marks of suffering or debility, while rabbits require to be supplied so constantly with food that they may be starved to death in

three days. In certain reptiles the capacity for abstinence is very much greater than in any warm-blooded animal. Frogs may be kept for many weeks, at least, without food, and Dr. Riddell, of New Orleans, has kept an *Amphiuma tridactylum* (aquatic lizard of the Southern waters) alive for twenty-eight months without feeding. I have myself kept a *Menobranchus lateralis* (great water-lizard of the Northern lakes) for eight months without food, at the end of which time he remained plump and vigorous. According to Agassiz, some kinds of turtles will withstand hunger for more than a year; and I have been informed by Mr. Kollar, superintendent of the Department of Reptiles in the zoological museum at Vienna, that the *Proteus anguinus* has been kept in that institution for six years, without any other food than the organic matter in suspension in spring water.

There is a similar difference in the degree of sensibility to pain possessed by different animals. Some, which bear abstinence from food without difficulty, have an acute sensibility to mechanical injuries; while others, which are very delicate in regard to privations, appear to have comparatively little sensibility to pain. The action of certain drugs and poisons also varies very much in intensity in different animals. Opium exerts but little narcotic effect on dogs, even in large doses; and while strychnine produces its peculiar effect on frogs almost as readily as on the human subject, hydrocyanic acid can be made to act on these animals only with the greatest difficulty.

But the most remarkable peculiarities exhibited by experiment on different species of animals are in its *indirect* or secondary results. Paralysis of the facial nerve, for example, in the human subject produces a loss of expression in the paralyzed half of the face, and a distortion of the features to the opposite side; and if both sides be affected, there is simply a complete loss of expression, together with some difficulty in the reception and mastication of food. But in the horse, if both these nerves be divided, the effect of the operation is fatal, and the animal dies from suffocation. This is because the horse breathes exclusively through his nostrils, which are large and expansible, performing regular respiratory movements like those of the chest. When the facial nerves are divided, the muscles which expand the nostrils are paralyzed and their sides collapse; and, as the animal cannot breathe through the mouth, owing to the peculiar position of the larynx, which is on a level with the posterior nares, he necessarily dies from suffocation.

You see a very similar arrangement of the parts in this head of the sheep. The cavity of the mouth has been opened by taking away

one lateral half of the lower jaw, and on looking backward towards the œsophagus, you see only the anterior surface of the epiglottis, which stands up in such a way that its edges are in contact with the lower surface of the soft palate, and the opening of the glottis is not visible from the cavity of the mouth, but communicates directly with the posterior nares; consequently, when I introduce the end of a bougie into the lower part of the trachea, and push it from below upward, it comes out, you observe, not at the mouth, but at one of the nostrils. These animals, accordingly, breathe through the nares, but not through the mouth; and in the horse, if the nostrils be obstructed by paralysis of their nerves, suffocation is inevitably the result.

Again, if the Third branch of the Fifth Pair of nerves be divided on one side in the human subject, and in most animals, there is hardly any other result than a loss of sensibility in the parts about the chin and lower lip. You will remember that this nerve, besides supplying the teeth of the lower jaw and the integument about the lower part of the face, has a motor branch which supplies the muscles of mastication, or those moving the lower jaw. But after division of this nerve on one side, mastication is still performed very well by aid of the opposite muscles, and but little inconvenience results; but if the same operation be performed in the rabbit, the two gnawing teeth in front of the upper and lower jaw no longer come together in their exact position, owing to the slight lateral displacement of the lower jaw. The teeth, accordingly, which do not meet and wear each other away, as in the natural condition, grow irregularly, and produce erosions and ulcerations of the mouth; and this, together with the difficulty of using the grinding teeth in the back part of the jaw, and of properly masticating a sufficient quantity of food, produces, finally, the death of the animal, in consequence of paralysis on one side of the third branch of the fifth pair.

It is evident, therefore, that we must exercise a certain reserve in applying the results of an experiment upon the lower animals to man, or to different species of animals. If these results be direct and immediate in the mode of their production, it is always safe to make application of them to the human subject; but if they be indirect, we cannot do so with certainty until we have learned all the successive steps by which they are produced. If we find, accordingly, that the destruction of a particular organ is always followed by the death of the animal operated on, we cannot conclude from this that the organ is essential to life in the human species, or that its destruction would be fatal to other animals. For the fatal effect which follows its injury

or removal may be indirectly produced by the disarrangement of other organs; and the degree or manner of its connection with these other organs may not be the same in the two kinds of animals.

VI. Lastly, it is very essential for the experimental physiologist to be acquainted always with the *individual peculiarities* of the animals upon which he operates; and for this purpose he should keep them under his observation, as a general rule, for a certain time before performing an experiment. In many cases this is necessary, simply to place the animal in a natural and healthy state of body. Dogs, for example, are usually in an unnatural condition for several days after being introduced to a new master, and shut up in a strange apartment. During this time they refuse their food, digestion is suspended, the intestinal secretions stopped, and the urine either totally suppressed or retained within the bladder. The animals remain, for the most part, quiet, and comparatively inexcitable, and do not exhibit their natural disposition. While in this condition, they are altogether unfit for any experiment upon the digestive or secreting organs, and the functions of the nervous system are also more or less disturbed. Usually this state of things lasts only for one, two, or three days, while, in some instances, it continues for nearly a week. In nearly all cases, however, there is more or less of it; and even where the animal appears from the first quite lively and contented, he almost invariably, during a certain time, refuses food, showing that he is not altogether in a natural condition.

At the end of two or three days, however, the animal becomes familiarized with his new quarters, and his nervous system and bodily organs return to their usual state. The intestinal secretions and the urine begin to be evacuated, and food is taken with relish. At the same time, the natural disposition of the animal is manifested, and for the first time it can be seen whether he is sluggish or excitable, quarrelsome or good-tempered, voracious or abstinent. It is singular to observe how suddenly this change sometimes takes place; so that a dog that has been kept for some days, and is just upon the point of getting through with this process of *acclimation*, will become so transformed in a single night as hardly to appear like the same animal.

As soon as the animal is restored to his usual condition, the observer will at once see that a certain acquaintance with his individual peculiarities is necessary, in order that the results of an experiment may be properly appreciated. These peculiarities relate not only to the irritability of the nervous system, the degree of intelligence, and the mental disposition, but they affect the entire organization, in its

functions of nutrition, secretion, muscular contractibility, &c. One dog will habitually feed with great appetite and relish, devouring large quantities, and always ready for it at the usual time. Another takes his food sparingly, and is fastidious as to its quality, requiring a much smaller quantity than the first, though, to all appearances, equally well nourished. In one animal the secretions are either more abundant or more easily excited than in another, the senses more acute, and the motions more varied and vigorous. It is particularly in experiments upon the nervous system, in which the effect of an operation is indicated so much by the state of the disposition, the posture, manner of using the limbs, &c., that previous observation of the individual habits of the animal is requisite; for where the effect of an operation or experiment is to be seen in the increase or diminution of a natural function, we are unable to appreciate these changes, unless we have already a proper standard of comparison in the ordinary habits of the particular animal used for experiment.

I have thus, gentlemen, endeavored to point out the principles which should guide us in the study of physiology, and to indicate the more important practical rules which it is necessary for us to observe. In studying the phenomena of the circulation, we shall find abundant opportunity for experimental investigation. These phenomena have many elements of a physical nature. The elasticity and contraction of the blood-vessels, the mechanical subdivision and connection of different parts of the circulatory apparatus, the exudation and imbibition of fluids, and the action of hydraulic forces, all have a certain degree of influence in the movement of the circulating fluid. The chemical constitution of the blood and its changes, its variations in color and density in different regions, also take part in the same phenomena. Finally, the influence of the nervous system in increasing or diminishing the flow of blood through an organ, the effect of increased or diminished respiration, and of the activity or repose of glandular organs, all require to be successively examined in detail.

LECTURE II.

SEPTEMBER 21, 1859.

Action of the Heart—Constant Character of Pulsations—Form and Position of Ventricles—Of Auricles—Crossing of Venous and Arterial Streams in Heart—Ventricular Valves—How Supported—Their Action—Difference between Mitral and Tricuspid—Closure of Valves from Behind Forward—Question of Regurgitation—Action of Arterial Valves—Position of Different Parts of Heart—Case of M. Groux—Other Similar Instances.

To-day, gentlemen, we shall pass directly to the study of the principal central organ of the circulation; that is, the Heart. This organ, though it does not constitute the only means of propelling the blood through the vascular system, is, perhaps, the most important of all. It is a central organ of impulsion for the circulating fluid, which continues its active operations, without cessation or relaxation, from the first appearance of life in the embryo, down to the last moment of adult existence. Not for one instant, during a life of sixty or seventy years, is the heart quiet; and it is certainly, therefore, the most important of the circulatory organs, in regard to the incessant and indispensable character of its functions, to be found in the whole body.

It is in the action of the heart, accordingly, that the manifestations of life continue longer than elsewhere, and that the symptoms of death show themselves most distinctly and unmistakably. All the other parts of the circulatory system may be interfered with, and their functions temporarily suspended; but so long as the heart continues to beat, so long the remainder of the circulatory organs may be recalled to activity, and again enabled to perform their customary functions.

In some of the lower animals, for example, when under the influence of ether or chloroform, the respiratory movements may be diminished to a remarkable degree in rapidity and force, sensibility and voluntary motion entirely suspended, and even the flow of blood through the capillary vessels seriously impeded, without immediate danger to life. You may notice this partial suspension of the capillary circulation in various parts of the body, sometimes by the excessive pallor of the lips, the face, the mucous membrane of the mouth, and occasionally of the internal organs, so that the circulation in their blood-vessels seems nearly to have ceased for the time being; and yet, notwithstanding the suspension of the capillary movement in certain parts, or over the entire body, and even though respiration may have ceased, so long as the heart continues to beat, it is possible that the rest of the circulatory apparatus may again be excited to activity. But let the

heart stop for one moment—let but a few of its pulsations be lost—and for some reason which we do not precisely understand, the animal organism can never again be reanimated, nor the operation of its functions restored.

This fact I have noticed very frequently in experiments upon the lower animals, when watching the effect of etherization upon the circulatory and respiratory organs. In the great water-lizard, for example, *(Menobranchus,)* while studying the phenomena of the circulation through the gills, I have seen the motion of the blood in the brachial capillaries become absolutely arrested under the influence of the ether, and continue inactive for a considerable time, the animal remaining meanwhile in a condition of profound anæsthesia; and yet recovery has taken place a few moments after the suspension of inhalation, and the animal has regained entirely its original activity, and the normal operation of its functions.

I have frequently seen, also, in dogs and cats subjected to the influence of ether or chloroform, the movements of respiration entirely cease; but so long as the beating of the heart could be felt through the ribs, however faintly, I have always anticipated with certainty the restoration of the respiratory function. Let the cardiac pulsations, however, be arrested, if only for a moment, and the fate of the animal is sealed; for no influence can restore them to action, and all the other functions depend, directly or indirectly, upon their continuance.

You will see, also, in studying the mode of its operation, that the heart is the most important of the circulatory organs, in regard to supplying the mechanical forces which assist in sustaining the movement of the blood. It is, as I have already said, a central organ of impulsion for the circulating fluid. It is a double forcing-pump, which receives the venous blood at one extremity, and sends forth arterial blood at the other. It is intermediate between the venous and arterial systems; and its function is the transmission of the blood from one to the other of these two great divisions of the circulatory apparatus.

We find that in all classes of animals which are provided with a heart, the essential points and characteristics of its anatomical structure are the same. The heart is nothing more than a special portion of the circulatory system; a hollow, muscular organ, the cavities of which are continuous with those of the remainder of the circulatory apparatus, and which differs from the blood-vessels simply in having its cavities surrounded by a considerable quantity of contractile tissue, and in being provided with valves, to regulate the flow of blood

and to give it its proper direction. Whatever may be the peculiarities in external conformation of this organ, whether single, double, or multiple—for there are some animals that have as many as sixty or seventy hearts (*Amphioxus lanceolata*)—we find that it always consists of a cavity or series of cavities, contracting by virtue of the muscular tissue which surrounds them, and furnished with valves so arranged as to open forward, and shut in a backward direction.

This double forcing-pump, then, is situated, as an organ of transmission, between the veins on the one hand and the arteries on the other. But in the human subject, and in many of the animals, the blood is not transmitted directly from the veins to the arteries by simple passage from one set of vessels to the other. There exists between the arterial and venous systems an intermediate organ—the lungs—in which the blood is converted, during its passage, from venous into arterial.

The heart, therefore, in the human species and in the higher animals, is, as I have said, a double organ. In the animals of this class there are two circulations—one, which has relation to the general tissues and organs of the body, and one which has relation to the lungs—one circulation and one heart, by which the venous blood is transmitted to the capillaries of the lungs, and another heart and another circulation by which the blood coming from the lungs is again transmitted to the arteries of the general system.

We find, accordingly, that in these instances the heart is divided into right and left cavities or chambers; the right chamber receiving the venous blood and transmitting it to the capillaries of the lungs, and the left chamber receiving the blood from the lungs and transmitting it to the capillaries of the general system.

This, however, is not all. For in the human subject, and in all the higher vertebrate animals, we have not only the heart divided into right and left chambers, but we have two cavities on each side, viz., the right auricle receiving the blood from the veins and delivering it into the right ventricle, and the left auricle receiving the blood from the lungs and delivering it into the left ventricle. In both cases the auricles are the receiving organs, and the ventricles the discharging organs. If we now examine the general characters of these two sets of organs, we shall find that the auricles are very different from the ventricles, both in their structure, form, and situation.

Here you have the fresh heart of an ox, from which the auricles have been removed; and you see, accordingly, the precise form of the ventricles fully exposed. You have here a mass, consisting simply of

the muscular walls of the ventricles, of a conical or pyramidal form. In its natural position, the base of the pyramid looks upward and backward, while its apex looks downward and forward.

In this second specimen, which is the heart of a dog, in its natural condition, you observe the relations, in size and structure, between the auricles and ventricles. You still recognize the ventricles as presenting nearly the same appearance as in the former instance. The left ventricle is divided from the right, externally, by a narrow furrow, directed from left to right, and from above downward, in which is lodged one of the cardiac arteries. All the portion situated below and to the left of this furrow, in which the blades of the forceps are now placed, consists of the left ventricle; and all the portion situated above and to the right constitutes the anterior surface of the right ventricle. You observe, also, the thin-walled and comparatively insignificant auricles, situated above and somewhat posteriorly to the plane of the corresponding ventricles.

The older anatomists and physiologists used to regard the ventricles as constituting, by themselves, the essential portion of the heart. They were accustomed to speak of the action of the ventricles as synonymous with that of the entire organ; and they considered the auricles not so much as portions of the heart, but rather as appendages of the venous system. In this view they were undoubtedly right to a very considerable extent. You observe, in fact, that the ventricles constitute very much the larger portion of the entire mass of the heart, while the auricles are comparatively insignificant in size and undeveloped in structure. When we come to study in detail the movements of the heart, we shall find, furthermore, that the action of the auricles is very different from that of the ventricles. It is the ventricles that, by their forcible and violent contraction, actually propel the blood, and carry on the circulation. The auricles act rather as receptacles for the blood, in its passage from the venous system, and are simply intended by their contraction to fill the ventricles, while it is the latter organs that perform the principal part of the circulatory task. Such are the general characteristics and relations of the different parts composing the heart.

Now, the course of the blood, as it passes from the veins towards the arteries, through the cavities of the heart, presents one peculiarity to which I will, in the first place, call your attention. You observe, that both the right cavities (auricle and ventricle) are situated upon a plane a little anterior to that of the left cavities. The right auricle is placed above and in front, and the left auricle above and behind.

The right ventricle is below and in front, the left ventricle below and behind. Both the ventricles, accordingly, are situated below, and both the auricles above. Both the auricles, as I have already remarked, serve as receptacles; the right auricle receiving the blood from the veins of the general system, the left that from the pulmonary veins. The blood, therefore, coming from the veins, enters the heart at its upper portion, by the venous orifices. It then passes, on the right side, from the auricle to the ventricle, in a downward direction; but, on arriving at the apex of the right ventricle, it immediately changes its course. It here makes a turn upon itself; and, instead of passing as before, from above downward, begins to pass from below upward, and from right to left. It thus arrives at a portion of the right ventricle, situated at an angle with the rest and leading towards the orifice of the pulmonary artery, which has received the distinctive appellation of the "conus arteriosus." In passing from the auricle to the ventricle, accordingly, the direction of the current is from above downward; but in passing from the ventricle to the pulmonary artery, through the conus arteriosus, it is from below upward. This change in the direction of the current of venous blood takes place, you will observe, in the anterior portion of the heart.

Now, let us examine the course of the blood, as it comes from the lungs, through the left side of the heart. From the lungs it passes, by the pulmonary veins, into the left auricle. From the left auricle it passes downward, to the left ventricle. Arriving at the apex of the ventricle, it again changes its course, and passes from below upward, and from left to right, towards the orifice of the aorta. It reverses, in this manner, the change of direction which takes place on the other side of the heart. We have here, accordingly, two streams passing through the organ in two opposite directions, both of them making their way, first from above downward, and then from below upward. But the venous stream turns from below upward and from right to left, in front of the heart; while the arterial stream turns from below upward and from left to right, in the posterior portion of the organ.

The two streams, therefore, venous and arterial, cross each other in the cardiac cavities, and finally emerge from the heart by its arterial orifices, in two different directions.

We will now proceed to the examination of the structure and mode of action of the *valves*, by which the various orifices of the heart are guarded. You see here several preparations, illustrating the manner in which these valves act. In the first specimen, the pulmonary

artery has been injected with alcohol, from above downward, distending its cavity and closing the arterial valves by the backward pressure of the injection. The anterior portion of the pulmonary artery has been cut away, exhibiting its three valves lying with their edges in contact, and closing completely the orifice which looks towards the ventricle. The same condition is also exhibited in the second specimen, which has been prepared in a similar manner.

In the third preparation, the right ventricle has been injected with alcohol by passing the nozzle of the syringe between the pulmonary valves, and injecting its cavity from before backward. The anterior wall of the ventricle having been afterwards cut away, the tricuspid valves are shown in a closed condition, and lying across the auriculo-ventricular orifice. You look directly into the cavity of the right ventricle and conus arteriosus, and see the oblique direction which the blood must take in passing from the ventricle to the pulmonary artery. The preparation having been hardened by the action of the alcohol, all its parts retain the precise position in which they are naturally placed at the moment of the ventricular contraction.

I would invite your attention, in the next place, to the manner in which the ventricular valves are held in place, at the time of the cardiac contraction. It is plain that, when the ventricle contracts upon its contents, it must act upon the blood with a considerable compressing power; and, if there were no anatomical contrivance to prevent it, the blood, while flowing outward through the arterial orifice, would regurgitate, with just as much rapidity and force, in the opposite direction. The membranous curtains, or valves, therefore, which prevent this regurgitation, and which are so situated and constructed that they may open forward and shut backward, must also be firmly supported in their closed position. This support is differently provided for in the auriculo-ventricular valves, and in those situated at the arterial orifices. In the tricuspid and mitral valves, we find a number of slender, rounded tendons, originating from the membranous edges of the valves, which pass from above downward, and are implanted into the fleshy columns arising from the sides and apex of the heart.

In this preparation you see the manner in which the mitral valves are supported by their tendinous cords. You observe, also, that there is an inequality in the breadth of the two membranous curtains forming the mitral valve. That situated towards the left side of the auriculo-ventricular orifice is the narrower of the two, while that on the right side is broader. The broader of these two curtains is placed directly over the orifice leading to the aorta; and when the blood is passing from the auricle into the ventricle, this valve naturally falls

downward and covers the entrance to the aorta, so that none of the blood passes into the aorta at this time. As soon as the ventricle contracts, however, both the valvular curtains being thrown backward to close the auriculo-ventricular orifice, the orifice of the aorta is opened, and the blood passes freely into it from the ventricular cavity.

In this bullock's heart, from which the auricles have been removed, but in which the auriculo-ventricular valves on each side have been left undisturbed, we can see the natural play of the mitral valves. The attachments of these valves are, as you see, fully exposed on their upper surfaces, owing to the removal of the left auricle; and you can look directly into the cavity of the ventricle, through the auriculo-ventricular orifice. I now place the pipe of a syringe in the aorta, with its nozzle directed towards the cavity of the left ventricle. The aortic valves have been destroyed, so that there is no difficulty in filling the ventricle with a watery injection, from the aorta backward. The pipe of the syringe being secured in this position, I now fill the ventricle with water, and you see that the mitral valves are lifted and brought together, so that the auriculo-ventricular orifice is effectually closed.

If we first fill the ventricle gradually with water, and then suddenly distend it by a forcible stroke of the piston of the syringe, you can see how completely the mitral valves prevent the escape of the fluid. The aorta is now distended by the backward pressure, and the ventricle filled to its utmost capacity; and yet the edges of the mitral valves are in perfect coaptation, and retain their natural position. The pressure is so great that the water escapes, you observe, in several thread-like streams from the cut surface, about the auriculo-ventricular opening—the divided orifices of minute blood-vessels ramifying in the substance of the heart, and filled from the coronary arteries at the base of the aorta. By withdrawing the piston of the syringe, the mitral valves collapse, and the cavity of the ventricle is opened; and by alternately filling and emptying the ventricle in this way, the valves can be made to alternately open and shut, thus imitating their natural play in the cardiac circulation.

Although, however, in this experiment, we can show with sufficient accuracy the movements and action of the valves themselves, it does not represent exactly the means by which their closure is effected during life, in the natural course of the circulation. Here we distend the ventricles and close the valves by injecting a fluid backward from the aorta. But nothing of this kind takes place in life. In the natural condition of the circulation, the ventricle is filled from the auricle and not from the aorta. The direction of the current of the blood is con-

stantly from behind forward, and not from before backward. It is true that if the ventricle be filled with blood while in a relaxed condition and should then contract, it would compress its fluid contents equally in all directions, and might thus be regarded as exerting a backward as well as a forward pressure. Still, this does not seem to be the mechanism by which the tricuspid and mitral valves are really closed; for the ventricle is, in point of fact, always filled in a direction exactly contrary to that which we have employed in the preceding experiment.

Some years ago Drs. Baumgarten and Hamernik, of Germany, came to the conclusion, from certain investigations directed to this point, that the ventricular valves, in the natural state of the circulation, were closed by a force acting, not from before backward, but from behind forward; that is to say, that they were closed by the pressure of the blood acting in a direction from the auricle towards the ventricle, and not by its backward pressure from the ventricle towards the auricle.

This statement may at first appear somewhat singular and difficult of comprehension; but a very simple experiment will show, I think, that it is a perfectly correct one. If we take the bullock's heart, arranged as before, with the auricles removed, and the attachments of the mitral valve exposed, by injecting the ventricle gently from the aorta backward, we can, as in the former instance, partly close the mitral valves. Now, with the valves in this partly closed condition, if we were to inject water downward into the ventricle *through the auriculo-ventricular orifice*, you would expect this would have a tendency to force open the valves. In reality, however, it has a tendency to close them more completely. I now direct a stream of water from above downward upon the half-closed valves, and you see they immediately become as distinctly and perfectly closed as if the injection had been made in a backward direction from the aorta.

We can even accomplish the whole process of filling the ventricle and closing its valve, by injecting it through the auriculo-ventricular opening. If I now pour a stream of water from above into the empty ventricle, you see the mitral valves gradually float upward and approximate each other, as the cavity of the ventricle fills with fluid, and at last a somewhat sudden and forcible injection completes the work, and leaves the valves instantly in a state of perfect coaptation.

It is in this way that the filling of the ventricle takes place in the natural course of the circulation. The contraction and relaxation of the auricle and ventricle do not alternate with each other in so regular and complete a manner as is sometimes described. The contrac-

tion of the auricle always precedes that of the ventricle, but there is still a considerable time before the occurrence of the cardiac systole, when the ventricle and auricle are both in a relaxed condition. During this time the blood flows steadily from the large veins into the auricle, and through the wide auriculo-ventricular orifice into the ventricle. Subsequently, however, the contraction of the auricle takes place, which by a quick, sharp impulse completes the filling of the ventricle, and at the same time closes the ventricular valves.

Then comes the contraction of the ventricles, which react instantly after the movement of the auricle. But you see from this, that the closure of the ventricular valves takes place, not at the moment when the ventricle itself contracts, but just before that time, viz., at the contraction of the auricles; and that consequently, when the ventricles react upon the blood which has passed into them from behind, their auricular orifices are already closed.

Regurgitation.—It has been thought by some observers that there is an essential difference in the efficiency of the various sets of cardiac valves, and in the completeness with which they guard the respective orifices at which they are situated. If we examine the mitral and tricuspid valves by the method employed above, viz., by injecting the cavity of the ventricles with water from the pulmonary artery and aorta, it is found that while the left ventricular valves (mitral) close promptly and efficiently, so as to bear a very powerful pressure without yielding, the closure of the right ventricular valves (tricuspid) is much less complete, allowing the regurgitation of a certain quantity of fluid between them.

Some years ago Dr. T. Wilson King described this peculiarity of the tricuspid valves, and attributed to it a special function for preventing over-distention of the heart, which he called the "safety-valve function of the right ventricle." Over-distention of the heart with blood would naturally have the effect of paralyzing its muscular fibres, in the same way as an excessive accumulation of urine destroys the contractile power of the bladder. Any such accumulation, accordingly, whether produced by deficient respiration, recession of the blood from the surface, or other similar cause, would be liable to produce a fatal effect by paralyzing the right ventricle, unless the excessive distention of the organ were prevented by opening an avenue of escape for the accumulated blood. Dr. King considered this as effected by the regurgitation of the blood through the right ventricular valves. These valves are attached by means of their tendinous cords and columnæ carneæ, partly to the right side of the septum of the ventricles,

and partly to the external wall of the right ventricle. This external wall is the one which most readily yields to pressure, and which, when forced outward by an accumulation of blood, or by the forcible injection of fluid, draws away with it a certain number of the tendinous cords, and so separates the edges of the valves to which they are attached.

Regurgitation will take place through the tricuspid valves, under the influence of a backward pressure, even when there is no such arrangement of tendinous cords, attached to the external or "yielding" ventricular wall, as that described by Dr. King. In the dog, for instance, all the cords belonging to the curtains of the tricuspid valve are attached, either directly or through the medium of fleshy columns, to the internal or solid wall of the ventricle—that, namely, which forms the septum between the two ventricles. And yet the tricuspid valve can readily be forced in the above manner.

Here is a dog's heart with the nozzle of a syringe inserted into the right ventricle through the pulmonary artery, and secured by ligature. By driving the injected fluid into the ventricle, you observe, the ventricle is at first filled, and none of the fluid escapes. But as soon as I distend its cavity beyond a certain point, its walls are forcibly separated, the action of the ventricular valves is no longer complete, regurgitation takes place from the ventricle to the auricle, and from the auricle to the veins, and the fluid escapes from the open orifices of the venæ cavæ.

This mechanism, therefore, or one similar to it, certainly exists as above described, and acts in the manner indicated when injections are employed to test the efficiency of the valves; and yet it is doubtful whether it possesses the importance which has been attributed to it in a physiological point of view, or whether the right ventricle can be regarded as exerting any peculiar and special function in providing against congestion and its consequences. It is true, that the tricuspid valves may be much more easily forced, by a backward pressure, than the mitral; but this is owing in very great measure to the fact that the left ventricle has excessively thick, muscular walls, which retain their figure under pressure and maintain their valves also in position, while the walls of the right ventricle are thin, and, comparatively speaking, easily displaced by pressure. Besides, a great difference will be seen in this respect, according as we examine the valves of the right ventricle when its walls are in a contracted or a relaxed condition. Immediately after death, when the walls of the ventricle

are relaxed and flabby, regurgitation through the tricuspid valves may be produced with the greatest ease; since they are maintained but loosely in their position, and a little force is sufficient to separate their edges. But if the same heart be allowed to remain until cadaveric rigidity is established in its muscular parietes, the tricuspid valves will then be found to close much more readily, and to resist pressure much more efficiently than before. We can easily understand, then, that though the valves may be separated by the pressure of an injection in the dead heart, they may still be so held in place during life by the contraction of the circular muscular fibres, that no regurgitation may take place. We must recollect furthermore, that in experiments like those detailed above, we operate upon the heart separated from its natural connections, which undoubtedly exert no inconsiderable influence in maintaining the proper coaptation of its parts. The normal attachments of the pericardium and great vessels, the sustaining pressure of the lungs and of the walls of the chest, which surround the heart everywhere with a gentle and equable support, are all lost when the organ is removed from the thorax and injected separately. I have often noticed, in making these experiments, that however carefully the injection may be performed, the *position in which the heart is held* has a great deal of influence on the completeness with which the valves resist pressure. In the mitral and even in the aortic valves, when fully distended by an injection, a very slight deviation of position, or undue lateral pressure on the neighboring parts, will frequently be sufficient to displace the edges of the valves, and to cause immediately a certain amount of regurgitation. The most favorable position for complete closure of the valves, which is no doubt secured during life by the normal attachments of the organ, requires to be maintained with some care in the separated heart.

It is important to observe, also, that in filling the ventricle by a backward injection from the pulmonary artery, we use a mechanism for closing the valves different from that which is employed during life. In the natural condition of the circulation, as we have already seen, the ventricular valves are closed by the flux of blood passing into the ventricle from the auricle. This is true for the valves upon the right side as well as for those upon the left; and though it is true, therefore, that by an artificial injection, directed from before backward, the tricuspid valves may be forced more readily than the mitral, there seems no good reason for concluding that in the normal state of the circulation the right ventricle is not as completely protected by its valves as the left. In each case the arrangement of the valves

and their support correspond with the strength of the muscular walls of the ventricles; for in each the valves are held in place, under ordinary circumstances, by a muscular force exactly equal to that which tends to displace them by a backward pressure of the blood.

The truth is, that *all* the valves about the heart are capable of displacement, and will allow regurgitation under an excessive backward pressure. This results naturally from the manner in which they are arranged. For since they are attached by their fixed edges to the circumference of the cardiac orifices, they will necessarily be drawn apart and opened by too great a distention of the cavities which they are destined to close. In the left ventricle it is comparatively difficult to do this, especially in large hearts, like that of the ox, owing to the extreme resistance of the muscular parietes; but it can, nevertheless, be accomplished by continued and forcible pressure. In the right ventricle, on the other hand, such a result follows more readily, since the auriculo-ventricular opening is wider, and its parietes more easily distended.

In injecting the right ventricle from before backward, the closure of the valves is never perfect until the cavity of the ventricle is tolerably well filled. Then the free edges of the valves, in a favorable position of the heart, come into apposition with each other, and fold over slightly, so that they touch each other throughout a narrow portion of their borders, and the remaining parts of the valve rise in a vaulted form towards the cavity of the auricle.

If a fluid, accordingly, be forced into the ventricle in moderate quantity, it accumulates in these vaulted portions beneath the valves, and by lateral pressure forces the borders of the valves into still firmer approximation. It is only when the distention is such as to draw apart bodily the whole valves and their attachments, that regurgitation takes place. The injected fluid then wells up in a bubbling mass from one or two points, or, if the pressure be great, may be sent out in a fine thread-like or ribbon-shaped stream from the spot where the adjustment of the valves is most imperfect.

The aortic and pulmonary valves, gentlemen, as you are aware, are supported in a manner somewhat different from the mitral and tricuspid. In all of them, as we have seen, the valves when full have an arched or vaulted form, their convexities looking backward, and their concavities forward. But the semilunar valves of the aorta and pulmonary artery, instead of being supported by tendinous cords and fleshy columns, are held in place by the form of their free edges, which

are arranged in the shape of festoons, and which by their lateral pressure afford each other at the same time a mutual support.

Here is the aorta of an ox, separated from the heart, but with its valves and their attachments still undisturbed. By injecting the artery forcibly with water from its peripheral extremity backward, you observe its valves fill out, become applied to each other by their free edges, and form at the cardiac extremity of the vessel a thin, but very firm and resisting triple-vaulted wall, which retains completely the injected fluid, notwithstanding the distended condition of the arterial parietes.

On increasing the pressure you see that the artery becomes especially dilated at its base into three bulging prominences, or ampullæ, corresponding with the concavities of the three semilunar valves. At the same time it is to be seen, that the first effect of an increased pressure, and the distention of the base of the artery, is to force the valves over further towards each other. Their edges are thus brought into closer apposition, and greater resistance afforded to the pressure from within. You can appreciate this power of resistance by feeling the induration of the coats of the artery and of its valves at the cardiac extremity. To make the resistance of the valves and the compressing power of the arterial walls still more evident, I now hold the vessel in such a position that the valves are directed downward, and the divided extremity, into which the nozzle of the syringe was inserted, uppermost. On turning the stop-cock and allowing the contained fluid a free exit, the water, you see, is thrown forcibly upward, to a height of over two feet.

It is evident, therefore, that in large animals, like the ox, where the column of blood is very heavy, and the action of the left ventricle powerful, an exceedingly severe pressure must be borne by the valves in order to maintain the natural course of the circulation. There is, accordingly, in this and some other species, a peculiarly-shaped bone, situated at the base of the heart, and so placed as to support the attachments of those valves which are subjected to the greatest degree of pressure. Here is a specimen of this bone (os cordis) from the heart of the ox. It is composed, as you see, of two curved limbs, of unequal length. Its normal situation in the heart is such, that the longer of these two limbs supports on its outside the attachment of the broad curtain of the mitral valve. On its inside, one of the semilunar aortic valves occupies the space included between the two limbs at their junction, while another is partially supported by the remainder of the longer limb. The supporting function of this bone is accord-

ingly confined almost entirely to the valves, aortic and ventricular, on the left side of the heart. Upon the right side, the force of the ventricular contraction being less, and the walls of the pulmonary artery, also, thinner and less powerful, less firmness is required in the attachment of the valves.

Let us terminate this portion of the subject, gentlemen, by some considerations relative to the position of the heart and its different parts in the interior of the chest. In most of the lower animals, the heart is nearly or quite central in position, occupying the median line. In the human subject its apex is turned to the left, so that the point of the heart strikes the walls of the chest usually at the fifth intercostal space, and a little inside a vertical line drawn through the left nipple. From constantly feeling the pulsations of the heart, therefore, in this situation, we are accustomed to speak and think of the organ as placed upon the left side of the body. Nevertheless, the heart is actually, even in the human subject, much more centrally situated than we are accustomed to believe.

The base and body of the organ are, in reality, placed in the median line, and it is only its apex which is deflected towards the left side.

It is impossible to judge of the natural situation of the thoracic organs, by inspection, after the chest has been opened in the usual manner, as practiced in post-mortem examinations. For by the opening of the thoracic parietes and consequent collapse of the lungs, all the support naturally afforded by these parts being taken away, the heart necessarily falls out of position, and its normal relations are more or less deranged. This difficulty has been partially avoided, in some instances, by thrusting long needles through the integument in various directions into the chest, and afterwards ascertaining, on opening the thorax, what points in the various organs have been penetrated by them. This mode, however, can give only an imperfect view of the position of the internal thoracic organs, though a correct one, so far as it goes.

We may also guard against unnatural displacement of the organs, by tying the trachea in the middle of the neck before opening the chest; then the lungs are prevented from collapsing when the support of the thoracic parietes is taken away, and the heart remains in its normal situation. By an examination conducted with these precautions, we find that the ascending portion of the arch of the aorta lies nearly in the median line. The bases of the aorta and pulmonary artery, and of course the aortic and pulmonary valves, are situated almost exactly in the median line, at the level of the third costal cartilage,

or the third intercostal space. The base of the aorta, where it begins to show itself above the body of the heart, is behind and a little to the right; while the upper part of the conus arteriosus and base of the pulmonary artery are placed in front and a little to the left. The aorta and pulmonary artery, accordingly, wind spirally round each other for a short distane. For, while the aorta emerges from the left ventricle behind, and thence comes forward, rising almost perpendicularly in the median line directly behind the sternum—the conus arteriosus runs upward and towards the left, along the front of the heart, and the pulmonary artery originating from it then turns almost horizontally backward, to bifurcate and send one of its divisions (right pulmonary branch) beneath the arch of the aorta.

Of the heart proper, the most superficial, and at the same time, most central portion, is the anterior surface of the right ventricle. This portion occupies the median line, and lies directly behind the whole width of the sternum from the level of the third costal cartilage downward to the sixth or seventh. The right auricle, on the contrary, is situated entirely to the right of the median line, sometimes even beyond the right edge of the sternum; and is placed, moreover, on a plane altogether posterior to that of the ventricle. The body of the auricle, in fact, does not come up at all in contact with the sternum; and it is only a portion of the appendix auricularis that overlaps, from the right, the base of the ascending aorta.

The left cavities of the heart are situated still more posteriorly, and show but little beyond the left edge of the right ventricle in an anterior view.

The following instances will show more precisely the usual position of the different parts of the heart, and the most common variations which are liable to show themselves in the human subject. In all these cases the trachea was first securely tied to prevent the escape of air and collapse of the lungs, and the sternum then removed by two longitudinal incisions, equally distant from the median line.

CASE I. In this instance, the upper lobe of the left lung, which was solidified with tubercular infiltration, covered entirely the heart and large vessels in the median line, and extended over to the right edge of the sternum.

The bases of the aorta and pulmonary artery were situated exactly in the median line, at the level of the third costal cartilage.

The ascending portion of the arch of the aorta was in the median line, from the third costal cartilage to the top of the sternum.

The appendix of the right auricle was placed quite to the right of the sternum, and behind the third costal cartilage.

The right ventricle occupied the space on each side of the median line, behind the whole width of the sternum, from the third to the seventh costal cartilage.

Case II. The upper lobe of the left lung, partly tuberculous and adherent, covered the upper part of the heart and large vessels in the median line, and to the right edge of the sternum.

The bases of the aorta and pulmonary artery were in the median line, at the level of the third intercostal space. The ascending aorta occupied the median line, from the third intercostal space to the top of the sternum.

The right auricle was rather more visible, in an anterior view, than in Case I., but was still placed altogether to the right of the median line—behind the third intercostal space and fourth costal cartilage.

The right ventricle occupied the median line and whole width of sternum, from the third intercostal space to the seventh costal cartilage.

Case III. In this instance, the ascending aorta extended, in the median line, from the upper edge of third costal cartilage to the top of sternum. The conus arteriosus, with its continuation, the pulmonary artery, was situated mostly to the left of the median line, and extended obliquely upward from the third costal cartilage on the right to the level of the first rib on the left.

The appendix of the right auricle, which was full of blood, was situated entirely to the right of the median line, at the level of the second costal cartilage and second intercostal space. It overlapped the base of the aorta, but did not touch that of the pulmonary artery.

The body of the right auricle, which was very much distended with blood, projected two inches and a half to the right of the median line.

The right ventricle occupied the median space, from the third to the sixth costal cartilage. The free border of the right ventricle, at the level of the fourth costal cartilage, was one inch to the right of the median line.

Case IV. The aorta was in the median line, but lay concealed, up to the level of the first rib, between the conus arteriosus and right auricular appendix.

The appendix of the right auricle was situated in the second intercostal space, altogether to the right of the median line. The conus arteriosus was also on the second intercostal space, to the left of the median line.

The right ventricle occupied the width of the sternum, from the third to the sixth costal cartilage.

Here are a number of injected specimens, with the heart in situ and the chest laid open. In all of them you can see illustrated the principal points already mentioned. The aorta and right ventricle are situated invariably in the median line, while the right auricle is placed posteriorly and on the right side; the left border of the heart, which is formed by the left ventricle, being also turned backward, and not showing itself very prominently in an anterior view.

This question of the exact position of different portions of the heart with reference to the walls of the chest—always of interest in a practical point of view—became very important in a case of congenital fissure of the sternum and partial exposure of the heart, which was exhibited here during the past year, and which attracted the attention of medical men in various parts of the country. This was the case of Mr. E. A. Groux, a man about thirty years of age, in whom there had existed from birth a complete fissure of the sternum, situated in the median line, and extending the entire length of the bone. This did not seem to be the result of a forcible division and separation of the bone, but simply of the fact that its two lateral halves, each fully formed, had never become united and consolidated with each other upon the median line. You will remember that the thoracic parietes, in the process of embryonic development, are formed simultaneously on the two sides, and grow forward until they meet in front, and there finally unite with each other. If their development be arrested, accordingly, towards the latter part of the process, there results a want of union between the two sides, and a permanent fissure on the median line. This fissure is more or less complete, according to the number of the different layers of tissue implicated in the deficiency.

In Mr. Groux it seemed to be only the bony tissue which was wanting. The two lateral halves of the sternum were separated from each other by a space of about one inch, at the widest part of the fissure; though by a constrained position of the limbs they might be separated to the extent of two inches. The interval between the bones was occupied by a strong fibrous layer which held the parts together, the whole being covered by perfectly healthy cutaneous investment. In the space, however, or fissure, in the median line, could be seen and felt a pulsating tumor, alternately rising and falling, and evidently consisting of some portion of the heart or its appendages.

Mr. Groux, who was a native of Hanover, in Germany, and who had attracted much attention among medical men in Europe, came to this country for the purpose of exhibiting his peculiar malformation to

the physicians of the United States. Though he had been examined by many hundreds of medical men, a great diversity of opinion existed among them as to what particular portion of the heart it was which produced the pulsations in the median fissure.

Some supposed it to be the aorta; very many regarded it as the right auricle; while a smaller number, among whom was Mr. Paget, of London, thought it to be the right ventricle.

A careful examination of the tumor and its pulsations, and a comparison of it with the natural position of the heart, convinced me that the last of the above opinions was correct, and that it was the right ventricle which showed itself in the space between the two halves of the fissured bone.

The heart, it was evident, did not deviate much from its normal position in Mr. Groux, since the stroke of the apex could readily be felt at, or just above, the fifth rib, and a little inside the plane of the left nipple. The organ, therefore, was not at all displaced laterally, and was only situated a little higher than usual with respect to the ribs, a condition not unfrequent in spare and thin-chested persons.

The pulsations of the tumor, visible at the widest part of the opening, extended from the second to the fourth intercostal space, and from the median line to the left edge of the fissure. They consisted of successive undulatory movements, which corresponded in frequency with the arterial pulsations. The tumor filled up and became prominent in a direction from below upward, and from left to right. Its contraction, which was synchronous with the impulse of the heart, consisted in a rapid wavy motion, which ran from above downward, and from right to left.

The tumor, therefore, was situated altogether to the left of the median line. This circumstance alone would be sufficient to show that it could not be the right auricle. For the right auricle, as we have seen, in the normal position of the heart, never comes up to the median line, but is situated entirely to the right of it; and in Mr. Groux's case it was also certain, as I just observed, that there was no lateral displacement of the organ, and no reason for believing the auricle to be out of its natural situation.

On the other hand, the situation of the pulsating tumor corresponded entirely with that of the right ventricle, in a heart placed a little higher in the chest than usual, and particularly with that part of it leading to the pulmonary artery, and known as the "conus arteriosus." The pulsations of the tumor also, which were wavy, progressive, and peristaltic, corresponded with those of the ventricle, which

have a similar character, and not with those of the auricle, which are quick, sharp, and momentary.

But one of the most positive indications of the ventricular character of the tumor was afforded by the changes produced in it by holding the breath, or by a long expiration. When Mr. Groux took a deep inspiration, followed by a long and very slow expiration, the tumor, which disappeared more or less completely at the time of inspiration, became very much enlarged towards the end of the expiration.

This enlargement took place in two directions: first, from left to right, until, at the level of the third costal cartilage, it extended quite over to the right edge of the fissure, and thence occupied the whole width of the fissure down to the fifth costal cartilage; and second, from below upward, on the left side, until it reached the level of the lower edge of the first rib.

In this condition, the tumor presented the exact shape of the upper part of the right ventricle and conus arteriosus, when distended with blood during a suspension of the breath. It is a great mistake to suppose, as we shall see in another lecture, that it is the right auricle which is exclusively, or even principally, distended by accumulation of blood during suspended respiration. The right ventricle suffers in a similar way. If the heart be exposed in a living dog, by opening the chest and keeping up artificial respiration, whenever the respiratory movements are suspended, the right ventricle and conus arteriosus enlarge and project in front of the heart, presenting a tumor precisely similar in form to that which showed itself in the median fissure in Mr. Groux, under the circumstances which I have just described.

All these appearances make it, I think, very certain that in the ordinary condition of the respiratory movements, in Mr. Groux, the pulsating tumor situated to the left of the median line and between the second and fourth intercostal spaces, was the conus arteriosus; and that during suspended respiration the upper part of the body of the right ventricle came into view, extending over to the right of the median line, and downward as far as the level of the fifth costal cartilage.

If the finger were pressed firmly into the space between the separated halves of the sternum, above the situation of the pulsating tumor, there was felt, exactly on the median line, a deep-seated, pulsating body, of a much firmer consistency than the other. This body was undoubtedly the ascending portion of the arch of the aorta. It gave to the finger the feeling of a tense, vibrating pulsation, almost entirely similar to that which is experienced by touching the aorta of a living animal, when exposed and separated by dissection from the surrounding parts.

Various other instances of fissure of the sternum have been observed, similar to that of Mr. Groux, accompanied with more or less exposure of the heart. Geoffrey St. Hilaire mentions a case in which the fissure was incomplete, existing only at the upper part of the sternum, and in which the pulsations of the aorta could be distinctly perceived in the median space. He also quotes another instance, in which the fissure was complete, extending through the whole length of the sternum, and in which the same malformation was presented by all the members of an entire family. Cruveilhier has related a remarkable case in which the fissure in the walls of the chest of a newly-born infant was accompanied by complete extrusion of the heart, this organ being entirely exposed, denuded of pericardium, and yet pulsating freely for some time after birth.

We have thus, gentlemen, gone through with most of the principal considerations relative to the structure, position, and mechanism of the heart. At the next lecture we shall study the peculiarities of its action during life, and more particularly the influence exerted upon it by disturbance of the respiratory function.

LECTURE III.

(September 23, 1859.)

Movements of the Heart during Life—Appearance of the Lungs in Respiration—Alteration of Blood in passing through the Lungs—Alternate Action of Auricles and Ventricles—Elongation, hardening, and twisting of the Heart—Effects of stopping Respiration—Change of Color in Heart and Blood—Distention of Right Auricle—Of Right Ventricle—Of Left Ventricle and Auricle—Passage of Venous Blood into Left Cavities—Distention of Aorta and Arterial System—Order and Mechanism of these Changes—Distribution of Venous Blood throughout Arterial System—Condition of Heart and Vessels at time of Death—Post-mortem Changes—Final stoppage of Circulation.

Here, gentlemen, is a full-grown dog, in whom, as you see, the chest has been opened, and the action of the lungs and heart exposed to view. A short time ago the animal was poisoned by the inoculation of woorara, and the nozzle of a bellows being immediately afterwards inserted into the trachea, artificial respiration has been kept up; so that the æration of the blood is still accomplished, and the pulmonary circulation continues as before. We can therefore examine, at our leisure, the action of the heart and the play of the lungs. We shall afterwards study the influence of various respiratory conditions upon the cardiac movements.

The lungs, you observe, in the first place, present a different hue according to their condition of collapse or distention. When filled with air, they are of a very light, pale rosy color—almost white; but when allowed to collapse, they become darker in hue, owing to the larger proportion of blood which they contain at that time. The color of the lungs, however, is at all times much lighter and paler than would usually be supposed by one who had only seen them as they appear after death.

In the natural condition of the parts, the anterior edges of the lungs considerably overlap the heart, so as to cover most of its surface; but by gently drawing them aside we can uncover very fully the heart and the large vessels in connection with it. In this animal, the pericardium has also been cut away, and the adipose tissue about the bases of the pulmonary artery and aorta carefully dissected off, so that the arterial trunks are fully exposed at their origin and easily distinguished from each other.

As the edges of the lungs are now drawn away in this manner, notice, if you please, the situation of the different parts of the heart and the course of the blood through them. Here, upon the right, you have the ascending and descending venæ cavæ through which the blood passes in two rapid and somewhat wavy streams, which meet in the cavity of the right auricle. The right auricle shows very distinctly the thinness of its walls, and in many places, particularly in the appendix auricularis, the bundles of muscular fibres are so far separated from each other that the dark color of the venous blood may be easily distinguished through the transparent endocardium. Below and in front of this portion, you see the right ventricle, with the conus arteriosus passing upward and to the left, and conveying the blood through the pulmonary artery to the lungs. The ascending portion of the arch of the aorta emerges from behind the base of the pulmonary artery, but soon becomes the more prominent vessel of the two, in the median line, to nearly the upper extremity of the sternum.

On turning over the heart towards the right side, the left auricle and ventricle, with the termination of the pulmonary veins, come into view. In the natural position of the organ, it is only the edges of its left chambers which can be seen from the front, their bodies being mostly concealed behind the right cavities and large vessels.

Now direct your attention, in the next place, gentlemen, to the effect of respiration on the color of the blood, as it passes through the heart and the pulmonary circulation. Here is the right auricle. It contains, as you know, the blood which has just arrived from the gen-

eral system, by the great veins; and the color of this blood, distinctly seen through the auricular walls, is a dark-bluish purple. On the opposite side of the heart, in a corresponding situation, is the left auricle, containing the blood which has just returned from the lungs. The color of this blood, also seen through the walls of the auricle, is of a brilliant scarlet, strongly contrasting with that on the opposite side.

We see here, then, in the living body, the change of color which characterizes the blood of the arterial and venous systems; and we are enabled to distinguish the exact point in the circulatory system at which this change takes place. The blood, immediately before its entrance into the lungs, is blue. Immediately after leaving them, it is red; and this change is incessantly repeated, as fresh portions of blood arrive at the right auricle and ventricle, pass through the pulmonary circulation, and return to the left cavities of the heart.

You observe, however, that while there is this difference in hue between the right and left auricle, there is no such difference in the color of the two ventricles. The ventricles both present a clear, fresh, red tinge, which is of precisely the same shade on the left side as on the right.

This is because the color presented to the eye by the auricles and the ventricles depends upon different conditions. In the auricles, the thinness and transparency of their walls, as we have already seen, allow the color of the blood which they contain to show through them; and the right auricle, accordingly, appears blue, while the left is red. In the ventricles, on the other hand, the muscular parietes are so thick and opaque, that they conceal entirely the color of the blood in their cavities, and show only the tinge of that which is circulating in their capillary vessels, and is intermingled with their muscular fibres. Both ventricles have the substance of their walls supplied by the same arterial blood, and consequently present the same general tinge externally. The color of the auricles, accordingly, is due to the color of the blood contained in their cavities; while that of the ventricles is due to the color of the blood circulating in their capillary vessels.

Such are the general appearances and color of the lungs and heart, in the natural condition of the circulatory apparatus.

Let me now call your attention, gentlemen, to several of the most important phenomena relating to the action of the heart and its different portions.

And first, as to the alternate movement of the auricles and ventricles.

The action of the entire organ consists, as you observe, in a series of constantly recurring and alternating contractions and relaxations. But it is easy to see, in the outset, that there is no very marked distinction in time between the contraction of the auricle and that of the ventricle. At least, there is no perceptible interval between these two occurrences. Although you see that the auricular contraction comes first, you nevertheless cannot perceive any actual pause or separation between it and the ventricular systole. The contraction of the heart has, therefore, the character of a continuous and peristaltic movement, which commences at the base of the organ with the contraction of the auricles, and runs immediately forward from them to the apex of the ventricles.

It is almost unnecessary to point out that, while this is going on, the two auricles always act simultaneously with each other, and the two ventricles also perform their contraction at the same time upon the right and left sides.

The next point to observe particularly is the hardening of the heart at the time when the ventricles contract. This hardening can be very readily felt by the finger, laid upon the surface of the organ, or by the hand grasping its substance. The fibres of the heart, like those of any other muscle, grow rigid during contraction, and the whole organ assumes a condition of firmness and tension. The hardening of the heart, therefore, is simultaneous with the contraction of its ventricles and the discharge of their contents. At the same time, the organ performs a well-marked spiral or rotatory movement, upon itself, directed from left to right. The spiral fibres and their contraction show themselves most distinctly just at the apex of the organ. At that point they are seen converging to a centre, and producing a kind of dimple, at each contraction of the heart, by their twisting or rotatory motion.

These three kinds of simultaneous action—the peristaltic contraction of the ventricles, the rigidity or tension of the heart, and its twisting motion from left to right—are the first phenomena relating to the cardiac movements which we have now to observe.

The next is that the heart, at the moment of the ventricular contraction, *elongates*. The action of the spiral and circular fibres of the ventricles is to draw the sides of the organ together at its base, and to shoot out or protrude the apex. As the apex starts forward in this way, it strikes against the walls of the chest, and produces the impulse or "shock" of the heart, so called, which is felt externally. It is easy to see here that the finger, laid upon the point of the heart,

is lifted with violence at every contraction of the ventricles. It is still more readily observed, when the heart is lifted gently so that the apex points upward, and then viewed from the direction of the diaphragm. The posterior surface of the organ, which is thus brought into view, has a very regular triangular shape, and shows very distinctly, at each pulsation, a narrowing of the base and elongation of the point.

Such are the principal points with regard to the action of the heart in a natural condition of the circulation and respiration, to which I shall ask your attention to-day. Let us now pass to the consideration of the phenomena presented by the circulatory apparatus when the respiratory movements are disturbed or suspended.

You observe, that while the circulation is going on in a natural manner, and while the lungs are alternately filled and emptied by the movements of respiration, the color of the blood, in passing through these organs, is completely changed from blue to red. The blood is arterialized while traversing the pulmonary circulation. It is converted from venous blood, which you see here in the right auricle, to arterial blood, which you see in the left auricle; and the substance of the heart itself is of a clear rosy tinge, owing to the bright arterial blood circulating in its capillaries.

I will now stop the artificial respiration, which has been kept up thus far, and allow the lungs to collapse. A change already begins to take place in the color of the heart. Its tinge is less brilliant and more dusky than before; and the longer respiration is allowed to remain suspended, the deeper and more bluish it becomes. The surface of the heart is now of a very dark, uniform purplish hue, which pervades the whole substance of the organ, and gives it an appearance quite different from that which it presents in a normal condition. The left auricle, too, which before presented a clear scarlet tinge, is now perfectly blue, and there is no difference in the color of the blood which shows through its walls and that contained in the cavity of the right auricle.

I now recommence the movements of respiration, and almost instantly you see a bright flush of the natural ruddy color, spreading over the surface of the heart, and the entire organ is rapidly restored to its normal appearance. The left auricle, also, has regained its original rosy hue, and the whole circulation goes on as before.

This change of color in the heart, in consequence of a stoppage of respiration, is due to a change of color in the blood. This fluid being no longer arterialized in its passage through the lungs, blue venous

blood is infiltrated throughout the substance of the heart, and communicates to it its own purplish hue. This is the first and most palpable effect which is produced by a stoppage of the respiration.

But there are other effects due to the same cause, to which I will now direct your attention. These are the distention of the cavities of the heart and accumulation of blood in different parts of the circulatory system, in consequence of a disturbance of the respiratory movements.

I now suspend once more the artificial respiration, and you will see the change in shape and size of the organ, produced by distention of its cavities.

At first, little or no alteration is to be observed in this respect; but after the lapse of a minute or two, you already see that the right auricle begins to be enlarged. This enlargement continues to increase as the color of the heart grows darker, and at last becomes very great, and the organ begins to labor under the load of accumulated blood. The auricle is now excessively distended, its sides bulging out far beyond their natural limits; and the heart is fast approaching that condition in which a continued accumulation would paralyze its muscular fibres, and finally arrest its pulsations.

The distention of the right auricle, in consequence of a stoppage of the respiration, is a circumstance which has been long known to physiologists; but what I wish you to notice particularly here is the fact, that this distention is not confined to the right auricle, but *extends also to the right ventricle.* The ventricle, as you see, is now, in point of fact, distended in the same way as the auricle. The whole right side of the heart is loaded with venous blood, and suffers in the same manner from its accumulation. When the movements of respiration are allowed to recommence, and the blood comes back arterialized from the capillaries of the lungs, the ventricle again begins to discharge its contents; it has already relieved itself of a portion of the load, and gradually returns to its original size.

Now, this is an effect which I wish to notice particularly, in the first place, because it is a part of the mechanism of the heart's action, under these circumstances, which is not fully understood, and which is not always described with perfect accuracy. When respiration is suspended, the venous blood accumulates on the right side of the heart, in both cavities; and the right ventricle becomes distended almost simultaneously with the right auricle. In point of fact, in viewing the actual experiment, we find that the distention of the ventricle takes place, if

anything, a little earlier than that of the auricle. At any rate, it certainly is not perceptibly later.

This fact is the more important to establish here, because it is one, I think, not generally appreciated. Almost invariably, where you see the effect of a stoppage of respiration on the heart's action discussed, it is the distention of the right auricle which is insisted on, but not that of the right ventricle. In the case of Mr. Groux, for example, to which I alluded in the last lecture, (fissure of the sternum,) the fact that the pulsating tumor in the medio-sternal space became enlarged during a prolonged expiration was regarded by some observers as a proof that it was formed by the auricle, and not by the ventricle. But from what we have just seen it is evident that the distention of the ventricle, in such a case, may be equally prominent with that of the auricle, and, in fact, would be more likely to cause a protrusion in the median line.

But we have thus far ascertained only a part of the phenomena which occur when the action of the heart is disturbed from stoppage of the respiration.

If we now repeat again the experiment of suspending the respiratory movements, you will see that it is not only the right auricle and ventricle which become enlarged from an accumulation of the blood, but *the left auricle and ventricle become distended also.* The cavities on both sides of the heart are gorged with blood to an equal, or nearly equal, degree. If, while the right cavities are now beginning to enlarge, you watch the left edge of the heart, you will observe that an enlargement is taking place as well in the left cavities; and if we now compare the two sides together, we should say, strange as it may seem, that the left ventricle is even more distended than the right. This fact introduces a new element into our explanation of the heart's action, and requires us to examine the theory of its mechanism a little more closely.

At first—so long as it was supposed that the distention of the heart, under stoppage of respiration, was confined to its right cavities—this distention was thought to be accomplished by a very simple process. It was explained in this manner. After the stoppage of respiration, the function of the lungs ceasing, the circulation in the pulmonary capillaries was also supposed to come to an end at the same time; and the blood, stagnating in the vessels of the lungs, thus exerted a backward pressure upon the right cavities of the heart, which, in consequence, became distended and overloaded. This backward pressure was communicated, it was thought, to the large veins near

the heart, and through them to the entire venous system—so that the blood accumulated in the veins and the right side of the heart, simply because it could not pass through the pulmonary capillaries, and thus reach the arterial system.

Now, this is really the case, to a certain degree, as we have already seen. At least, such an accumulation actually takes place upon the right side of the heart. But it takes place in the ventricle as well as in the auricle; and the distention of the ventricle is, if anything, prior to that of the auricle, showing that it is produced by a backward pressure. It is a kind of regurgitation from the lungs, owing to an obstacle in the pulmonary circulation.

Such is the idea most commonly entertained with regard to the production of these phenomena.

But this explanation will not account for all the appearances which are observed. For you have seen that the distention of the heart shows itself equally upon both sides; or, if anything, the left auricle and ventricle are distended more than the right cavities. How are we to account for this distention of the left cavities? Is it that the blood is expelled in large quantities from the lungs, and so accumulates in the left cavities of the heart, not being able to pass through them? This cannot be the correct explanation; for we have seen that the blood, so far from passing in greater abundance through the lungs after respiration is suspended, passes less readily than usual. There is an absolute obstacle to its flow through the pulmonary vessels. It cannot, therefore, be the blood coming from the lungs which distends the left cavities of the heart, so much as an accumulation of blood which retrogrades, or which tends to retrograde, from the general circulatory system backward to the left cavities.

Now, we may convince ourselves that this is in reality the case, by examining the order in which the changes just mentioned present themselves. To illustrate this, I will repeat some experiments which I have recently performed in reference to this subject. From their results you will see reason to believe that the distention of the left side of the heart, after stoppage of the respiration, is a distention which takes place from before backward—that is, a distention from the general system towards the left ventricle and auricle. One of these experiments was performed in April last, in the presence and with the assistance of Dr. Sands, of New York, and Dr. Da Costa, of Philadelphia.

Experiment.—April 5th, 1859. A full-grown dog was poisoned

with woorara. The chest was then opened, and artificial respiration kept up by a bellows inserted into the trachea.

The following observations were then made on the changes in the appearance and action of different parts of the heart, after suspending the artificial respiration—the lungs being allowed to remain, during each trial, in a state of complete collapse :

I. The rapidity of the heart's action, immediately after the stoppage of respiration, is the same as before, viz., twenty-eight beats in ten seconds.

II. The right auricle begins to swell distinctly before the left auricle.

III. Both ventricles swell moderately soon after the stoppage of respiration, but we cannot tell which, if either, begins to enlarge first.

IV. On the right side, the ventricle and auricle both become distended—we think, but without being too positive, the ventricle first.

V. On the left side, we are sure that the ventricle begins to swell before the auricle.

VI. The pulmonary artery begins to swell a considerable time before the pulmonary veins or the left auricle. The pulmonary veins and the left auricle swell at a later period, nearly at the same time, but the auricle a little the first.

VII. Blue blood appears in the pulmonary veins and the left side of the heart, before there is any *excessive* swelling of any part of the organ.

You observe here, gentlemen, that the order of distention of the cardiac cavities is always from before backward. On the right side the auricle and the ventricle become distended nearly at the same time—but the ventricle, if anything, rather the first, and on the left side the ventricle and auricle enlarge before the veins; while the pulmonary artery enlarges considerably before the pulmonary veins and the left auricle. Everywhere, accordingly, the ventricle swells before the auricle, and the auricle before the veins; and we shall soon see that the great arteries leading from the heart swell before either.

This, then, leads us, in the course of our examinations, to a new and very remarkable fact, which has hitherto entirely escaped observation. It is this—that not only do the right ventricle and pulmonary artery become distended almost at the same time with the right auricle, and not only do the left cavities of the heart become distended in the same, or nearly the same, degree with the right cavities—but the *aorta itself*, and the commencement of the arterial system, become distended from a similar cause, at the same time.

This fact of the distention of the aorta is of great importance, as it furnishes the key to the whole mechanism of the influence of the stoppage of respiration.

You will find that the order in which these changes present themselves, after the lungs are allowed to collapse, is as follows: There are two distinct stages in this process, marked by essentially different phenomena. In the first period there is a *very slight* swelling of the cavities of the heart, which takes place almost immediately after the stoppage of respiration. At this time, blue blood begins to pass through the capillaries of the lungs, and to appear in the left side of the heart. This is a point which I wish you to notice particularly. After respiration has stopped, the circulation through the lungs does not stop—but, on the contrary, the blood continues to pass through the capillaries of these organs. The only difference is that, under these circumstances, the blood is no longer arterialized. But, so far from the pulmonary circulation being arrested by this, the blue blood passing through the lungs, and still retaining its venous character, begins to pass through the pulmonary veins into the left cavities of the heart. I have found, in experiments directed to this point, that after the suspension of respiration, the unaërated blood passes through the lungs so rapidly as to fill the cavity of the left auricle in thirty seconds. The venous blood thus passes into the left auricle, from the left auricle to the left ventricle, and from the left ventricle to the aorta, whence it is distributed through the arterial system.

Now comes the second stage of the process. As soon as the venous blood has fairly found its way into the arterial system, there begins an excessive distention of the cavities of the heart, *but preceded by a distention of the arterial system and the aorta.* The arterial system and the aorta become engorged, because the venous blood which they contain, arriving at the capillaries, is not fit to circulate through them. It accordingly stagnates at the capillary system, and immediately begins to exert a backward pressure upon the arteries. From the arterial system the engorgement extends to the aorta, and from the aorta to the left cavities of the heart. The blue blood which continues to pass through the lungs, and of which the arterial system cannot disgorge itself, accumulates consequently in the aorta and in the left cardiac cavities.

We will now repeat, in this animal, the experiment of stopping the respiration, as the heart, I presume, has now completely recovered from the effects of the last trial. The two auricles, right and left, contain now, as you see, respectively blue and scarlet blood. The

two ventricles present their natural size and action, and the pulmonary artery and aorta are seen above, the aorta occupying precisely the median line, the pulmonary artery running obliquely upward and a little to the left. The aorta, as you also see, is very slightly distended at each pulsation of the ventricles, and reacts by its own elasticity, immediately afterwards. On touching it with the end of the finger it is felt to be tolerably firm, but elastic and flexible, and it can be partially compressed by the finger without much difficulty.

Now, on stopping the movements of respiration, we see reproduced all the appearances which we have heretofore noticed, and in addition this new phenomenon of the arterial distention. The blood soon passes in an unaërated condition into the left cavities of the heart. The left auricle already contains so much dark blood that you now see little or no difference in color between it and the right auricle. The heart begins to be distended also at this time, upon the left side as well as upon the right; and both the left cavities, auricle above and ventricle below, are now distended, not with arterial, but with venous blood.

But while these changes are going on, the aorta also, you observe, suffers an alteration in size. This swelling of the aorta is very manifest before there is any excessive enlargement of either the right auricle on the one side or the pulmonary veins on the other. When the heart begins to labor under the accumulated blood, the variation in size of the distended aorta at each pulsation becomes much more marked. At each contraction of the ventricles it is now excessively distended, and then partially collapses, though it constantly remains unnaturally enlarged. If the finger be laid upon it, it is felt to be excessively tense and resisting, and to have lost the flexibility and compressibility which belong to it in the natural condition.

A recommencement of the respiratory movements again restores the normal state of the circulation, and the heart and pulmonary artery and aorta gradually relieve themselves of blood.

It is evident, therefore, that the distention of the aorta precedes that of the other central organs of circulation. The following experiment will illustrate some of the more essential particulars in reference to this point.

Experiment.—Sept. 9th, 1859. A dog was inoculated with woorara three and a half hours after feeding. The chest was opened, and artificial respiration kept up through the trachea.

The lungs were then allowed to collapse, and the effect upon the circulatory organs noted as follows:

I. Unaërated, blue blood passes through the lungs, so that the blood in the left auricle is completely dark-colored in thirty seconds.

II. There is a *slight swelling* of both right and left cardiac cavities soon after the suspension of respiration, as observed in previous experiments.

III. Some minutes afterwards, the heart begins to labor, and a marked and excessive *distention* of the same cavities takes place, both auricles and both ventricles being filled with dark blood.

IV. But the pulmonary artery and the aorta are also distended at this second stage of the process, and their distention is equally marked with that of the ventricles. The ascending portion of the aorta becomes distended to $\frac{1}{4}$ more than its original diameter; and the pulmonary artery to nearly $\frac{1}{8}$ more than its original diameter. The distention of the aorta is both more marked and more promptly produced than that of the pulmonary artery, and *even precedes, if anything, the excessive distention of the ventricles.*

V. At the time also that the aorta is so enlarged, there is *no sensible distention of the venæ cavæ*, in the neighborhood of the heart.

VI. After this state of things has continued for a short period, the aorta becomes more excessively distended at the time of each cardiac contraction, and again partly collapses at the time of relaxation; the blood evidently regurgitating then from the aorta into the ventricle.

VII. After artificial respiration is recommenced, bright scarlet blood passes round into the left auricle, so as completely to restore its natural color in fifteen seconds. The aorta and pulmonary artery remain distended and indurated for a few minutes, but gradually return to their original size and softness.

VIII. If respiration be allowed to cease with the lungs kept moderately full of air, (by tying the trachea after an insufflation,) all the above phenomena follow, as described, but at later periods. For example, blue blood begins to fill the left auricle, in this instance, only after about two minutes. The other changes also are proportionably delayed, but are not essentially different in character from the foregoing.

Now, there are one or two points in these experiments which I wish to notice more particularly than we have yet done. They relate to the manner in which the circulation of the blood, or its continuous passage through the vascular system, becomes disturbed and finally arrested. For there is a period, immediately after stoppage of the respiration, during which the chemical changes of aëration and arterialization of the blood are suspended, but in which its continuous

movement still goes on as before. The auricle drives the blood into the ventricle, and the ventricle into the aorta; and when the aorta is expanded by the impulse of the cardiac contraction, its subsequent reaction drives the blood which it has received onward towards the capillaries. Each successive portion of the heart and arteries impels its volume of blood farther and farther upon its course, and thus contributes to keep up the incessant round of the circulation. Even the blue, unaërated blood, returning from the lungs, passes from the auricle into the ventricle, from the ventricle into the aorta, and from the aorta into the arterial system.

But soon afterwards the distention of the aorta begins to show itself, which we have already noticed; and, at the same time that it begins to fill with venous blood, its pulsations become more marked and vibratory. They are more distinctly visible to the eye, and more perceptible to the touch. Now, why is this? It is for the same reason that the pulsations of an artery become more marked after it is tied, as in surgical operations, amputations, and the like. There is an obstacle to the onward passage of the blood which did not exist before; and the influence of this obstacle is felt in an increased tension and vibration of the artery.

After a short period, however, the distention of the aorta becomes excessive, and then a change is at once perceptible in the efficiency of the heart's action. Its contractions become labored, and, as it were, spasmodic, with longer intervals between them. At each contraction of the ventricle there is an increased expansion of the aorta with the new volume of blood driven into it. But when the aorta reacts after this expansion, the blood is no longer driven forward as before, and distributed through the arterial system, but regurgitates through the aortic orifice and again fills the relaxed ventricle. It is then evident that the heart fails to maintain the circulatory movement of the blood. The obstacle to its passage in the arterial system is too great to be overcome by the cardiac impulse, and the natural continuous flow of the blood through the vascular system is replaced by an alternating flux and reflux, from the ventricle into the aorta, and from the aorta back again into the ventricle.

Another exceedingly remarkable fact in this connection is, that the great veins, as we have seen, in the neighborhood of the heart, do not participate in this engorgement of the ventricle and the aorta. All the cavities of the heart may be enlarged and full of venous blood. The aorta also may be enlarged, and crammed to its utmost tension with the same venous blood, while at the same time the venæ

cavæ are hardly, if any, larger than in the natural condition of the circulation.

We are now able, I think, to understand what takes place in the circulatory system, when the aëration of the blood is interfered with. In point of fact, after the stoppage of respiration, the venous blood, which naturally belongs only to the venous system, passes round into the arterial system. It can pass through the capillaries of the lungs, it can find its way into the left cavities of the heart, and from the left cavities of the heart it can find its way into the arterial system, but from the arteries it *cannot* find its way through the capillaries of the general system. Here is the obstacle which opposes the passage of the impure blood, and which arrests the continuous movement of the circulation.

Accordingly, we find that in such an experiment it is not the great veins which become distended after stoppage of the respiration. The disturbance which results is not principally because the blood finds a difficulty in passing through the lungs, and so distends the right auricle and the great veins, and finally presses backward upon the capillary system. This is the manner in which the process is usually described; but you see it is not the way in which it actually takes place. The order and direction of these changes, on the contrary, are precisely the opposite. The reaction takes place, not from the great veins to the capillaries, and thus through the capillaries to the arterial system; it is the arterial system which first becomes distended, then the aorta, then the left cavities of the heart. While the whole arterial system, accordingly, is filled and distended with venous blood, which the capillaries will not allow to pass, and while the whole heart, auricles and ventricles, is distended in the same manner, the venæ cavæ, both superior and inferior, as we have seen, are not particularly enlarged, and, in fact, are rather less abundantly supplied with blood than usual.

I will now demonstrate, by again stopping the respiratory movements in this animal, that under these circumstances, the blood not only passes through the lungs to the left cavities of the heart, but is also distributed from the left cavities throughout the entire arterial system.

I make an incision here over the situation of the right femoral artery, the chest remaining open, and the thoracic organs exposed, as before. I now open the sheath of the vessel, taking care not to wound the small muscular branches which you see passing off towards the inner and outer part of the thigh. Here you have the femoral artery fully exposed. Now, on stopping the respiration, the pulsations of the

vessel become very soon much more strongly marked than before. The artery raises itself visibly at each pulsation and exhibits a tremulous movement, owing to the greater obstacle to the flow of blood which is established by the want of aëration. It is already, also, assuming a darker color, showing that the blood which circulates in it is acquiring a venous tinge instead of the bright arterial hue which belongs to it. Blue blood, in fact, has at this moment passed into the left cavities of the heart, and the aorta is beginning to be distended and indurated. I now open the femoral artery by a transverse section, and you see the blood which flows from it is perfectly venous in character.

On recommencing the movements of respiration, the tension of the artery is very soon diminished, and in a few seconds, as you see, it again contains arterial blood, with a perfectly natural ruddy tinge.

In that short space of time, therefore, the venous blood had penetrated throughout the arterial system, and was afterwards rapidly replaced by arterial blood, as soon as the function of respiration was reestablished.

The following are the phenomena, accordingly, which show themselves in the circulatory organs, after stoppage of the respiration. First, passage of unaltered venous blood through the lungs, to the left side of the heart. Second, entrance of this venous blood into the aorta, and its general distribution over the arterial system. Arrived at the capillaries, the venous blood first meets with a serious obstacle to its passage. What is the precise nature of this obstacle, we do not as yet understand; but it is certain that the venous blood does not pass freely and readily through the capillaries of the general system, but is blocked and stagnated in this part of its course, and that then by a backward pressure it begins to engorge and distend the arteries. We cannot suppose, however, that the venous blood is absolutely and entirely arrested in the capillaries, but only that its passage through them is rendered much more slow and difficult than before. For when respiration again begins, as we have seen, and the blood is aërated at the lungs, though the entire arterial system be at that moment full of venous blood, arterial blood will yet in a few moments find its way into the arteries everywhere from the heart outward, and restore the natural course of the circulation. The venous blood, in this case, must escape through the capillaries in order to give place to the aërated and arterialized fluid.

The obstacle to the passage of venous blood through the capillaries, therefore, is partial, not complete. But it is still sufficient to produce

an immediate backward engorgement of the arterial system. Then the aorta becomes distended at its origin, and the left ventricle and left auricle in succession, being unable to relieve themselves of blood through the arterial system, become distended in a similar manner. During this time, the same kind of engorgement takes place in the pulmonary artery and the right cavities of the heart; though the distention of the pulmonary artery is never so excessive as that of the aorta, either because there is less obstacle to the passage of venous blood through the lungs than through the general capillaries, or because the injecting force of the right ventricle is less than that of the left, or because less blood is supplied by the capillaries to the veins, and by the veins to the right side of the heart. In either case, the principal accumulation is certainly in the arterial system.

Soon afterwards the heart begins to labor in its pulsations, and the blood regurgitates, between the pulsations, from the aorta into the ventricle. The excessive accumulation then paralyzes the contractile power of the cardiac walls, and death takes place, with all the cavities of the heart distended with venous blood.

Let us now see what further changes take place at the moment of death, when the circulation actually comes to an end. For though the appearances just described are those which follow directly upon a stoppage of the respiration, they are not such as present themselves in a post-mortem examination, some hours later. An alteration must, therefore, take place in the course of the phenomena, at some time either during or after the death of the animal. Observation shows that this alteration begins to take place when the heart ceases to act.

The periods which we have thus far examined have been characterized by an accumulation of venous blood in the arterial system and left cardiac cavities, followed by an imperfect action of the heart and regurgitation of blood from the aorta into the ventricle. The arterial system is at this time distended to its utmost. For the venous blood which it already contains can only with the greatest difficulty pass through the capillaries, and the powerful contraction of the left ventricle drives into it at each impulse a fresh supply. This state of things continues so long as the action of the ventricle remains sufficiently vigorous to give the blood an impulse towards and into the arteries. But the continued distention, which the heart suffers, soon begins to paralyze its action more effectually; and at this time it can be seen that *the engorgement of the arterial system diminishes, while that of the heart increases.* The regular, rhythmical action of the left ventricle stops. It no longer discharges any blood into the aorta; and the aorta and

arteries generally, by the elastic resiliency of their own walls, and the slow passage of the venous blood through the capillaries, gradually relieve themselves of the load which they contained, and return to their original size. They even become smaller than in the natural condition of the circulation, for the blood of which they relieve themselves is now no longer replaced by fresh supplies from the lungs and heart. The fibres of the heart during this time exhibit an irregular, tremulous, vermicular contraction, which is to be seen first in the auricles, and afterwards in the ventricles, but which is entirely insufficient to produce any proper contraction of the cardiac cavities, or any impression on the blood which they contain. The left auricle is at this period so enlarged as to be quite equal in size to the right; and of the two auricles, both of which are then of precisely the same color, the left is very much more tense and firm than the right. The pulmonary veins are also quite tense, while the venæ cavæ, on the right side of the heart, are even then hardly enlarged beyond their natural size. The left auricle, however, in the last stages of the heart's action, diminishes sensibly in size, while the right auricle remains distended; and the venæ cavæ in the immediate neighborhood of the heart fill up more or less with the blood which has come round to them from the capillary system. The pulmonary artery remains distended longer than the aorta, but finally relieves itself, and loses altogether its unnatural size and tension.

At the moment of death, accordingly, when all action of the heart has finally ceased, the arteries are empty or nearly empty of blood, and the venæ cavæ in the cavity of the chest are moderately engorged. The right auricle and right ventricle are distended with blood, and the left auricle is reduced to about half the size of the right; while the left ventricle is still also distended, rounded and bulging in shape, elastic and fluctuating to the touch, and, like the right ventricle, full of liquid venous blood. This condition of the heart can be seen at any time by allowing the respiration and circulation to come to an end in the manner which I have just described.

But after death another change takes place, which produces a still further alteration in the relation of the parts. This consists in a post-mortem contraction of the walls of the heart, showing itself most prominently in the left ventricle, which is the most muscular and powerful part of the organ. This alteration in the condition of the heart is undoubtedly similar in its nature to the cadaveric rigidity which shows itself, some time after death, in the external muscles of the trunk and extremities. It is the cadaveric rigidity of the heart. But it may be

established much more promptly than the corresponding condition of the external muscles. I have seen the left ventricle of a dog, one hour after death, quite firm and resisting to the touch, when no sign of cadaveric rigidity could yet be perceived in the limbs; and even three and four hours after death there may yet be no distinct cadaveric rigidity in the external muscles, while this muscular induration is very fully developed in the left ventricle.

The effect of this post-mortem contraction of the cardiac fibres is more or less to obliterate the cavity of the left ventricle and to empty it of blood. A similar effect is produced, to a certain extent, in the right ventricle, which perceptibly diminishes in size within a few hours after death. But the muscular walls of this portion of the heart are too thin, and their action too feeble, to overcome the accumulation, and the right ventricle remains permanently distended with a considerable quantity of blood. The left ventricle, however, continues to contract, until it is very much reduced in size, and its sides brought nearly or quite in contact with each other.

This fact explains why it is that although the left ventricle is full of blood at the moment of death, it is almost invariably found to be empty in a post-mortem examination made some hours subsequently. Its post-mortem contraction gradually forces the blood from its cavity into the arterial system, and the arteries, retaining their elasticity, continue to force it onward through the capillaries, as before. This passage of the blood, therefore, which is accomplished during life by a series of successive, vigorous, cardiac pulsations, takes place after death by a slow and imperceptible post-mortem contraction of the ventricle, analogous to the cadaveric stiffening of the voluntary muscles. The blood which it contained filters slowly through the arterial and capillary systems, and appears finally in the venous trunks and branches. Here it accumulates, by gravitation, in the most dependent parts of the body, and in those veins which are not compressed by the muscles in a state of rigidity.

The great veins of the chest and abdomen thus become the principal receptacles for the blood after death. The venæ cavæ themselves, in the immediate neighborhood of the heart, have even seemed to possess in a slight degree the property of post-mortem contraction, and to exhibit accordingly, like the right auricle and ventricle, traces of cadaveric rigidity. The presence of striped muscular fibres in the walls of the veins in that situation, is sufficient to explain the existence of such a property. Notwithstanding this, the venæ cavæ in the cavity of the chest still remain quite full of blood, which accumulates, however,

to the most remarkable degree in the portal vein, and in the abdominal vena cava below the liver.

If the thoracic organs accordingly be examined some hours after death, when cadaveric rigidity is fully established, the left ventricle and auricle are found to be very much contracted and indurated, and nearly empty, containing not more than one-quarter or one-eighth part as much blood as the corresponding cavities on the opposite side. The aorta is also very much diminished in size, and nearly empty; while the venæ cavæ, and particularly the inferior vena cava in the abdomen, are distended much beyond their natural size. There is a certain amount of induration in the right auricle and right ventricle; but these cavities are still full of blood, and comparatively soft and yielding to the touch. The pulmonary artery contains only a moderate quantity of blood, though more in proportion than the aorta; while the pulmonary veins are full. The blood, of course, under these circumstances, is everywhere perfectly dark and venous in color.

We thus see how it is that, some time after death, the blood is collected mostly in the right side of the heart and the large veins, although the immediate effect of a stoppage of respiration is to produce an engorgement of the arterial system and the left cardiac cavities.

I will now, gentlemen, stop altogether the artificial respiration in the animal which we have been using for experiment; and we can then notice in their order all the phenomena which present themselves, and see how the action of the heart finally comes to an end. The left cavities already contain dark blood, which passes through into the arterial system. Now the heart begins to labor, and at the moment this takes place, the distention of the aorta commences to show itself.

In the second stage of the process, which is now beginning, you see the increased and labored action of the cardiac cavities, the aorta expanding widely at each pulsation, and then partly emptying itself, by regurgitation, into the ventricle. You notice also, at this moment, that notwithstanding the immense distention of the cardiac cavities, the venæ cavæ are not particularly enlarged. It is the arterial system which is engorged at this period, not the venous.

The contractions of the heart are very slow, but they are still perfectly regular, and have otherwise their natural character, with the exception that they are more forced, and recur with less rapidity than usual. If respiration were to be re-established in this condition of the

circulatory organs, I presume we might still recall the heart to its normal activity.

But if you allow the suspension of respiration to continue beyond a certain limit, even for a few seconds, you will find the heart paralyzed; and that paralysis having once taken place, the action of the organ cannot be recalled, although the lungs be brought again into play.

While the pulsations of the heart are now going on very slowly, you will observe a very curious fact, which was not perceptible when the organ acted with its normal rapidity, viz., a distinct interval of time between the contractions of the auricle and ventricle. The whole order of the heart's action, in fact, can be more easily analyzed, when it is thus retarded by an obstruction to the circulation. The auricle can be seen to contract first, and then the contraction of the ventricle follows after a slight interval.

The heart has now arrived at that condition that the circulation of the blood is no longer accomplished. Though the ventricles still contract, yet their contractions are not sufficient to discharge the blood which they contain, and force it into the arteries. Accordingly, the distention of the arterial system, you see, has already very much diminished, and the aorta has nearly returned to its original size. How does this happen? How has the artery got rid of its contents? Partly, it is evident, by a regurgitation of blood into the ventricle, which no longer fills up the artery by its own contraction, and partly by a slow filtering away of the blood through the capillary system into the veins.

The contraction of the cardiac fibres is now excessively irregular, and operates only in such a way as to distend the various parts of the organ by alternate and altogether local contractions and relaxations. These movements are no longer harmonious with each other, and of course are entirely inefficient to produce any definite effect on the circulation.

These irregular and localized movements of the cardiac walls continue for some time, becoming more feeble and uncertain, until they finally come to an end. The contraction of the ventricles ceases before that of the auricles, and that of the left auricle before that of the right; in which, as you are aware, the natural irritability lingers for a longer period than anywhere else. Finally, the activity of every part of the organ is exhausted, and all indications of vitality come to an end.

LECTURE IV.

(September 24, 1859.)

Nervous Influences affecting the Heart's Action—Rhythmical Character of Pulsations—Not dependent on the presence of Blood—Experiments—Influence on Heart of destroying Medulla Oblongata—In Warm-Blooded Animals—In Reptiles—Continuance of Heart's Action after destroying Medulla and Spinal Cord—Galvanization of Pneumogastric Nerve—Effect on Heart's Action—Nature of this Influence—Effect of Narcotic Poisons on Heart—Action of Ether and Chloroform—Mode in which Anæsthetics prove fatal—Action of Hydrocyanic Acid—Of Woorara—Varieties of Woorara—Difference in their Mode Action.

After having thus far, gentlemen, gone through with the physical phenomena presented by the heart's action, we will to-day study some of the nervous influences which act upon the organ, and which regulate the manner in which it propels the blood through the vascular system.

The most remarkable of the nervous phenomena connected with the action of the heart, in its normal condition, is the singular regularity and persistence of its motions. The heart differs in this respect from all the other muscular organs, voluntary and involuntary. The voluntary muscles of the limbs and trunk contract only when stimulated by the nerves of motion; and the involuntary muscular organs, such as the bladder, the intestines, the œsophagus, and the uterus, are excited at certain periods by the presence of foreign bodies, or by the accumulation of their own contents. All these muscles appear to be normally in a state of quiescence; and are thrown into contraction only under the influence of an occasional stimulus. But the heart acts with a continuous and regular pulsation. Not only are its actions incessantly repeated without any apparent external stimulus, but there is a certain rhythm in the mode of their production, and its different motions follow each other in a certain definite order.

This rhythm or order of the heart's action is as follows: There are, in the time occupied by an entire cardiac pulsation, three distinct and successive periods. In the first of these, the whole heart is in a relaxed condition, receiving passively the blood which flows into it from the veins. This period occupies about two-fifths of the whole time of a pulsation. Then the second period follows, which is marked by the contraction of the auricles, and which is about one-fifth of the whole. Immediately afterwards, there follows the ventricular contraction. This, as we have seen, is continuous with that of the auricles, and

occupies the remaining two-fifths of the entire revolution. Then the period of rest recurs, followed by the auricular and ventricular contractions, as before.

The heart, therefore, differs from the other muscular organs in two important particulars: first, its incessantly recurring contractions and relaxations; and secondly, the regular order in which its different movements spontaneously take place.

These distinctive characters are not to be accounted for by the anatomical structure of the organ. Its muscular fibres, when examined by the microscope, do not exhibit any such peculiarities as would explain their remarkable irritability, or their unusual power of continued action. The nervous filaments distributed to the walls of the heart, and the nervous ganglia with which it is provided, are similar in appearance to those met with in other internal organs. The minutest anatomical examination would not lead us to suspect that it differed from other muscles in its physiological endowments.

How are we to account for this continued and rhythmical character of the heart's action? Various explanations have been proposed, some of which are quite inadequate, others more or less satisfactory. One of them supposes that the heart is excited to contraction by the stimulus of the blood acting upon its internal surface.

This explanation is one of the most popular and plausible of all those which have been offered. According to this view, the heart is at rest so long as it remains empty, or nearly empty, of blood; but so soon as its cavities become distended to a certain degree with the circulating fluid, its muscular fibres are stimulated to contract, just as the intestines or the œsophagus are excited by the presence of food. Immediately after a contraction, therefore, the whole heart is relaxed, because its natural stimulus is absent. But as soon as the blood, flowing in from the large veins, has filled the auricles to a certain point of repletion, they contract and drive the blood into the ventricles. The ventricles, thus distended, respond in their turn to the stimulus, and discharge their blood into the arteries. Once empty, both auricles and ventricles are of course relaxed, and remain quiescent until a fresh accumulation of blood again excites them to contraction in the same order as before. Thus the successive cardiac movements of systole and diastole are kept up by the alternate entrance and exit of blood to and from the cavities of the heart.

It is very possible that the presence of the blood in the auricles and ventricles may have a certain influence in determining the contraction of their muscular fibres. Indeed, it is very easy to see that an un-

natural accumulation of blood, within certain limits, from mechanical obstruction of the circulation, gives rise to more powerful contractions of the organ, and thus appears to act as a direct stimulant to its muscular parietes. Still, this hypothesis does not wholly explain the phenomena in question. For the heart will continue to beat, even though it be empty of blood. It may even be cut out of the chest, and separated from all its connections, and of course drained completely of its fluid contents, and yet will continue to execute alternate contractions and relaxations as before. In the warm-blooded quadrupeds, these movements of the separated heart last only for a few minutes; but in the reptiles they often continue for many hours. They have been seen to go on in the eel for six hours, in the torpedo for nine hours, and in the salmon for twenty-four hours.

In order to ascertain the influence of various conditions upon the post-mortem contractions of the heart, I have tried the following experiment. Three turtles were taken, of the same species, and in the same general condition. In the first, (No. 1,) the brain and medulla oblongata were broken up, and the anterior portion of the shell taken away, so as to bring into view the heart, still covered with the pericardium, and retaining its connection with the great vessels. In the second turtle, (No. 2,) the brain and medulla were also broken up, and the heart, exposed as before, still retained in the pericardial sac, but the cardiac cavities were immediately drained of blood by dividing all the vessels leading to and from the heart, beyond the borders of the pericardium. In the third case, (No. 3,) the heart was simply cut out of the body, drained of blood, separated from the pericardium, and left exposed upon an earthen plate. The pulsations of the heart in these three instances continued as follows:

Heart's Pulsations.	No. 1. Brain and Medulla oblongata destroyed. Heart in situ.	No. 2. Brain and Medulla destroyed. Heart in situ, but drained of blood.	No. 3. Heart cut out, divested of pericardium, and drained of blood.
After 20 minutes.	2 per minute.	12 per minute.	6 per minute.
" 40 "	2 "	12 "	8 "
" 1 hour.	4 "	11 "	8 "
" 1 h. & 20 m.	2 "	11 "	7 "
" 1 h. & 40 m.	2 "	11 "	10 "
" 2 hours.	2 "	11 "	11 "
" 2½ "	2 "	10 "	12 "
" 3 "	2 "	11 "	10 "
" 3½ "	3 "	11 "	10 " Becoming feeble.
" 4 "	4 "	12 "	8 " Excessively feeble.
" 4½ "	4 "	8 "	0
" 6½ "	6 "	14 "	
" 8½ "	3 "	16 "	

In No. 1, the movements of the heart, which had nearly or quite ceased at the 22d hour, were again excited on opening the pericardium and exposing the surface of the organ to the contact of air, when it continued to pulsate very slowly till after the 33d hour.

In No. 2, the rhythmical action was equally persistent; and forty-five hours after the commencement of the experiment, though the ventricles had stopped, the auricles still pulsated four times per minute.

It seems difficult, therefore, to attribute the movements of the heart altogether to the stimulus of the blood contained in its cavities. This stimulus, if it be the efficient cause of the cardiac contraction, must depend either on the simple *contact* of the blood with the surface of the endocardium, or on the *distention* of the cavities to a certain point by the circulating fluid. But the lining membrane of the heart is always in contact with blood, when the ventricles are partially empty and relaxed, as well as when they are full and on the point of contraction. If the simple *contact* of blood, therefore, affords the requisite stimulus, it is not easy to understand why the contraction of the ventricles should be intermittent. On the other hand, if it be the *distention* of the cardiac chambers which determines their movement, why does this movement continue after the large vessels, and even the heart itself, have been opened, and only a minute quantity of blood, to say the least, remains in its cavities?

When the heart is cut out of the chest, and so drained of blood, its movements continue, as we have seen, for a considerable time. In this case, it is true, the continued action of the organ might be referred to the unnatural stimulus of the air with which it is brought in contact. The contact of air, as is very well known, will produce contractions in the fibres of the voluntary muscles after death, and these contractions will recur at longer or shorter intervals, according to the degree of irritability possessed by the muscles. I have seen the exposed muscles of the shoulder, in a turtle, contracting occasionally for many hours after death; and the contact of air undoubtedly has a similarly stimulating effect upon the cardiac fibres. It might be supposed, therefore, that the natural stimulus of the blood were replaced by that of the air, after excision of the heart, and that this accounted for the continued movements of the organ.

Notwithstanding this, however, such experiments are not without value, for they demonstrate that the empty and separated heart will continue to beat long enough to show, at least, that *the blood is not the only stimulus capable of maintaining its rhythmical action.* Besides, in the comparative experiment which I have just detailed, you see that in

the second turtle, where the heart was drained of blood, but still contained in the pericardium, and protected from the contact of air, its pulsations continued as regular, as frequent, and for a longer time than in the heart which was separated and exposed to the air. They were also more frequent, and nearly or quite as long-continued as in turtle No. 1, where the medulla oblongata was simply broken up and respiration brought to an end.

These facts certainly show that the contact of the blood is not the only cause upon which the *continuance* of the heart's action is dependent. It is equally impossible to explain by such an hypothesis the *rhythmical and successive character* of the cardiac movements. For the heart, when emptied of blood, still performs its pulsations in a sensibly natural manner. Its different chambers contract and relax in regular order, and in a definite succession, as before. There appears to be a certain nervous connection between its different parts, which associates their action in a particular way, independently of external or local stimulus. If the frog's heart be cut out of the body, emptied of blood, and laid upon a plate, its alternate auricular and ventricular contractions will continue for a considerable time. After these spontaneous pulsations have ceased, the heart still remaining sensitive to external stimulus, if one of the auricles be pinched between the blades of a forceps, or touched with the point of a needle, not only will the auricle itself contract, but its contraction is immediately followed by a pulsation of the ventricle, as it would be in the natural condition of the circulation. In this case there is no stimulus applied directly to the ventricle, either by the passage of blood or otherwise, and yet its movement is intimately associated with that of the auricle, and follows it in the natural order of time.

The persistent and rhythmical action of the heart, accordingly, depends upon a property inherent in the organ itself, for it survives the removal of both natural and artificial stimulus. The continued movements of the separated heart show, furthermore, that its peculiar action does not depend directly upon its connections with the nervous system. In endeavoring to explain its properties, therefore, we can only rely upon the facts which are demonstrated by experiment, and which show that the heart is distinguished from other organs by peculiar vital endowments, and that these endowments depend directly upon its own structure and upon the physiological constitution of its muscular fibres.

In every muscular organ are two distinct and opposite states or conditions, viz.: a state of contraction and a state of relaxation. These

two conditions are complementary to each other, and necessary to each other's existence, like the sleeping and waking conditions of the human body. For in the act of contraction, the muscular fibre uses up and expends its vital contractility or force, as a Leyden jar discharges its electricity. The contraction of the fibre, therefore, exhausts itself, and is necessarily followed by a state of relaxation. In the relaxed condition, on the other hand, the processes of nutrition go forward, which re-establish the physiological properties of the muscular fibre, and restore to it the power of contraction. In every muscle, accordingly, these two states naturally alternate with each other. During relaxation, the contractile force accumulates; during contraction, it is expended and discharged.

In all cases, furthermore, the physiological constitution and properties of the muscular tissue remain for a certain time after the death of the animal and the stoppage of the circulation. The muscular fibre, it is true, depends for its supply of nourishment upon the blood. But it still contains within itself the materials which are immediately necessary to its organization; and, until these are exhausted, it will retain its physiological properties, more or less perfectly, though the circulation may have already come to an end.

All the muscles, therefore, both voluntary and involuntary, retain their irritability for a certain time after the death of the body, and their fibres will still respond to a mechanical stimulus, by contracting, as they would do during life.

In the case of the heart, however, both during life and after death, this muscular irritability and contractility are manifested in a peculiar way. No sooner is the organ relaxed, and its nutrition momentarily re-established, than it contracts again spontaneously. Its physiological power is manifested, not by a single contraction, but by a series of successive pulsations, which follow regularly upon each other. This peculiarity of its action is to be seen after death as well as during life; in the drained and empty heart, as well as in the organ which is full of circulating blood. With the heart, therefore, it is the power of regular pulsations which becomes gradually exhausted after death, in the same way as ordinary muscular irritability disappears from the other muscular organs. When the heart is separated from the body, its pulsations, you remember, continue for a time, but afterwards grow feebler, and then cease. Now, if we take a heart which has thus become partially exhausted and quiescent, and irritate its substance by touching it with the point of a needle, this irritation will often give rise, not to one pulsation, but to a series of them. A single applica-

tion of the stimulus, accordingly, produces a number of successive contractions, for it has the effect of exciting again the natural action of the organ, and this action is one of repeated and rhythmical pulsation.

The peculiarities of the heart's movements, therefore, can only be attributed to a power which is inherent in its own organization, and which is independent, to a certain extent, of its connection with other parts.

There are, however, certain influences exerted upon the heart by the nervous system, which we shall now proceed to study in detail. For though the heart does not derive its power of contraction from the nervous centres, since it will continue to contract when completely separated from the body, yet its movements are susceptible of being *modified* in a remarkable degree by influences communicated through the nerves. We see this often enough in the effect of moral impressions, which accelerate or retard the pulse; and Bernard has found that the heart's action may be increased by the mechanical irritation of a spinal nerve, too slight to produce any signs of pain in the animal.

The first of these influences which we shall notice, is that exerted, by the destruction of certain parts of the brain and of the spinal cord, upon the heart and the rest of the circulatory system. Sudden and violent destruction of a considerable portion of the nervous centres has an immediate and depressing effect upon the heart's action. Breaking up the brain and medulla oblongata with a steel needle, in frogs and turtles, produces a partial and temporary paralysis of the heart. Afterwards the organ gradually recovers, and resumes its natural action. The sudden violence inflicted on the nervous centres produces a shock, which is communicated through the nerves to the heart, and depresses its action for a time. When the heart is cut out of the body, the mutilation of the parts and the severing of the nervous connection has a similar effect, and the organ remains for a few minutes quiescent. Its pulsations then begin to return, slowly and at long intervals. As it recovers strength, its action becomes more forcible and regular, and may afterwards continue, as we have seen, for many hours.

In the higher animals, injury of the medulla oblongata alone often produces a temporary exeitement of the heart's action. Its pulsations become rapid and tumultuous, and can sometimes even be perceived through the walls of the chest. This, however, soon passes off, and the organ returns to its ordinary rate of movement. The entire brain has also been removed, in quadrupeds, without arresting permanently the cardiac movements. Provided, therefore, the respiration be not

interfered with, we can destroy both the brain and the medulla oblongata without destroying the heart's action.

But there is a difference in the indirect effect produced upon the circulation by destruction of the medulla oblongata, in the cold-blooded and in the warm-blooded animals.

In all cases, the immediate result of such an operation is a complete stoppage of the respiratory movements. In man and the higher animals, the process of respiration is naturally exceedingly active. The movements of inspiration and expiration follow each other with rapidity, and the air in the lungs is rapidly exhausted by the blood circulating through the pulmonary capillaries. In these instances, accordingly, the destruction of the medulla oblongata, which puts a stop to respiration, soon puts a stop also to the action of the heart; for the aëration of the blood cannot be arrested without disturbing, as we have already seen, the circulation in consequence. But this influence is exerted upon the heart, not directly, but indirectly. It is not, properly speaking, the destruction of the medulla oblongata that stops the heart's action. The destruction of the medulla arrests the movements of respiration, and the stoppage of respiration arrests the movements of the heart.

In the cold-blooded reptiles, however, respiration is not so continuous and unceasing a process as in the quadrupeds. The air in the lungs is exhausted more slowly, and the accumulation of carbonic acid takes place less readily and abundantly. The *mechanism* of respiration in these animals is also different. The air is not drawn into the lungs by a movement of inspiration, but is forced into them by a muscular action like that of swallowing, and is then retained there until expelled by another muscular effort Although the respiratory movements, accordingly, be interrupted in these animals, yet the lungs still contain air enough to provide for the slow respiration which they require, and to allow for the continued circulation of the blood.

In the reptiles, therefore, while breaking up the medulla oblongata puts a stop to the movements of respiration, as it does in the human subject and in quadrupeds, it does not on that account put a stop to the action of the heart. At least, this action will go on for a considerable time, after such an injury has been inflicted.

Here is a turtle, in which the brain and medulla oblongata were destroyed three hours ago. The operation is readily accomplished in these animals, by introducing a steel needle through the foramen magnum and breaking up the nervous centres by moving the point of the instrument in various directions. The heart, which is still inclosed in

the pericardium, has been exposed to view by taking away the anterior part of the shell, and removing some of the muscles in this situation. It continues to pulsate, as you observe, with regularity, though not with so much force as at first. The circulatory system is beginning to feel the influence of the exposure of the internal organs and the interruption of respiration; but it will nevertheless still perform its functions for some time longer.

There is one anatomical peculiarity in the heart of the turtle which you may notice here. The point of the heart is attached to the inner surface of the pericardium by a loose band or bridle of fibrous tissue, which retains the organ in position, at the same time that it allows a certain amount of movement within the pericardial cavity. One or two fine red vessels can be seen running through this fibrous band, from the pericardium to the anterior surface of the ventricle. These pericardial attachments of the heart are also found in some other reptiles, such as serpents and lizards, as well as in turtles.

In this animal, gentlemen, you observe, the destruction of the brain and medulla oblongata has not arrested the action of the heart. On the contrary, the organ has continued its movements for more than three hours. I will now carry still further the destruction of the nervous system, by breaking up the spinal cord throughout its entire length. I introduce the end of a wire into the spinal canal, and, pushing it downward, pass it through the whole length of the spinal column. The spinal cord is now completely destroyed, and yet little or no effect is produced on the movements of the heart. These movements continue as before; or, if they show any alteration, it seems that the irritation has rather had an effect to stimulate them and increase their force. The same experiment, tried upon the frog, shows a similar result.

It is extremely interesting to notice, in this connection, that the capillary circulation is regulated in a different manner from the action of the heart, and is differently affected by injury of the nervous centres. This difference may readily be observed in the frog, by exposing the heart as usual, by cutting away the integument and muscles of the anterior portion of the body, and by placing at the same time the tongue or the transparent web of the foot under the microscope. We can then judge at any time of the condition of the capillary circulation, as well as of the cardiac movements. I have found, in this way, that if the brain and medulla oblongata alone be destroyed, the capillary circulation continues for at least two hours. But if the entire cerebro-spinal axis be destroyed, by thrusting a wire through the

spinal canal, though the heart may continue to beat for three hours, the capillary circulation comes to an end within five minutes.

I will now proceed, gentlemen, to speak of a very remarkable influence exerted upon the heart through the medium of the pneumogastric nerve. This influence is of so peculiar a character that it may almost be considered as an exception to the ordinary mode of operation of the nervous system.

In experimenting upon the cerebro-spinal nerves, the most constant and uniform of all the phenomena noticed are those which follow upon the irritation or division of the nervous trunks and branches. Irritation of a nerve, by galvanism or otherwise, acts as a stimulus upon the organ to which it is distributed. Ligature or division of the nerve, on the other hand, paralyzes the organ and suspends its function. These effects are so palpable and so regular in their production, that we often rely upon the excitability of a nerve, in order to investigate the excitability of its corresponding organ. They are particularly well marked and uniform in the motor nerves, distributed to the muscles. Galvanization of a motor nerve produces contraction of the corresponding muscle. Division of the nerve, on the contrary, causes paralysis of the same part. These are the most invariable and well-understood of all the phenomena connected with the nervous system.

But a singular anomaly presents itself in the action of the pneumogastric nerve upon the movements of the heart.

Here is another turtle, (a snapping-turtle,) in which the brain and medulla oblongata have been destroyed, and the heart exposed, as before. The action of the heart, as you see, is still vigorous; the auricles and the ventricles alternately filling and emptying themselves, with a perfectly regular and natural motion.

I now isolate the pneumogastric nerves in the neck, and separate them from the neighboring parts by passing beneath them a couple of glass rods; then, by bringing in contact with them the two poles of an ordinary galvano-electric apparatus, I pass through them a current of electricity. You see that, after the passage of the electric current has continued for a few seconds, the action of the heart is arrested, and the organ remains quiescent. You will notice also the very remarkable fact that the heart stops beating, not at the moment of contraction, but at the moment of relaxation. While its movements are suspended, the organ is not in a state of spasmodic contraction, but is relaxed, and remains in that condition while the electric current is passing through the nerves.

On ceasing the galvanization, the heart remains quiescent for a second or two, and then again commences to beat; at first with less than its usual rapidity, but in a short time it recovers itself completely, and the regular cardiac pulsations go on as before.

By again applying the poles of the battery, the same phenomena may be produced a second time. If the current be very powerful, the heart stops at once. If it be only moderately strong, the pulsations continue for a short time, but recur more slowly than usual, and then cease. The ventricles dilate, but fail to contract again at their regular time, and the heart's action stops. You observe that, while in this condition, the heart is not in any degree engorged or distended with blood; it is simply in a state of rest. Its rhythmical action ceases during the galvanization of the nerve, and recommences after the galvanization is stopped.

Here, then, we have a phenomenon quite unexpected, and peculiar in character. Irritation of the pneumogastric nerve, instead of exciting the heart's action, stops it; and this action begins again after the irritation ceases to be applied to the nerve.

How is this peculiar influence conveyed to the heart, when the pneumogastric nerves are galvanized? Is it a reflex action, by which the irritation of the nerve is first conveyed to the medulla oblongata, and then reflected outward, by the fibres of the great sympathetic or otherwise, towards the heart? Or, is it a directly sedative action conveyed downward to the heart by the fibres of the pneumogastric nerve itself? We can settle this question in a very simple way. For if the pneumogastric nerves be divided in the middle of the neck, and the two upper extremities, which are still in connection with the brain, be then galvanized, no visible effect is produced; but if the current be passed through the lower portions of the divided nerves, the heart stops as before, and all the phenomena take place as in our former experiment. The influence exerted by the pneumogastric upon the heart, therefore, in this instance, is direct, and not reflex.

The same effect may be produced upon the heart by galvanizing the medulla oblongata, at the origin of the pneumogastric nerves. This can very readily be seen in the frog, by exposing the heart in front and the medulla oblongata behind, severing the connection of the medulla with the spinal cord, and then passing through its substance a stream of electricity, at the level where the pneumogastric nerves originate. On commencing the current, the heart stops and remains dilated. On discontinuing the current, the cardiac pulsations begin again. But if the pneumogastric nerves be previously divided, no

effect is produced on the heart by galvanizing the medulla. The influence, accordingly, whatever it may be, which arrests the heart, in this instance, is conveyed from the medulla oblongata directly to the organ itself, through the fibres of the pneumogastric nerve.

Galvanization of the pneumogastric, therefore, acts in a very exceptional way, by arresting or retarding the contractions of the heart, to which its fibres are distributed. This fact is so much the more remarkable, since, if the galvanic current be applied directly to the heart itself, its effect is not to arrest, but to excite the muscular contractions of the organ, as in the case of other muscles.

The *division* of the pneumogastric nerve has an equally remarkable effect upon the cardiac movements. If the two pneumogastric nerves be divided in the middle of the neck, the pulsations of the heart, instead of being suspended or retarded, are accelerated. This fact has been known for some years, and has been frequently verified by different observers. In some instances, Bernard has found the heart's movements to be doubled in rapidity after section of the pneumogastrics; and this effect seems to be invariable in its occurrence, at least in the warm-blooded quadrupeds.

The influence of this nerve upon the heart, accordingly, if we were to judge simply from these facts, would appear to be entirely peculiar in its nature. Its direct influence would seem to be not a stimulating, but a restraining one. The heart would appear to have a power of motion of its own, which is held in control and moderated by the action of the pneumogastric nerve; so that when the nerve is excited by galvanism, its influence, being increased, overpowers completely the heart's action and holds it in check; and when its influence is abolished, and the heart left to itself, the cardiac movements are accelerated, because the controlling power is withdrawn.

Such would be the simplest way of explaining these curious phenomena. But there are several facts which show that this explanation is not entirely correct.

In the first place, this peculiarity of action does not reside so much in the pneumogastric nerve as in the heart itself. For the pneumogastric, as we know, is distributed to other muscular organs besides the heart; for example, to the larynx, œsophagus, and stomach. Now, it is found that the excitement or paralysis of this nerve acts upon the last-named organs in the same way as if the experiment were tried upon other motor nerves. For if the trunk of the pneumogastric nerve be galvanized, the effect of this operation is to excite the muscular fibres of the stomach, and stimulate them to contraction. On the

other hand, its division paralyzes the stomach, and puts a stop to its peristaltic movements. The same thing is true with regard to the muscles of the larynx and those of the œsophagus. Irritation of the pneumogastric excites these organs; its division paralyzes them. It is the heart, therefore, which has a peculiar relation to the nervous influences; but the nerves with which it is supplied have the same general properties with those distributed to other organs.

In the second place, when the pneumogastric nerves are divided, by a transverse section, though the heart's action is accelerated, it does not become more powerful. On the contrary, the *force* of the cardiac pulsations is diminished, at the same time that they become more rapid. Indeed, it is a general rule with regard to the movements of the heart, as we shall see hereafter, that whenever their rapidity is increased they become less powerful; and this rule holds good in the present instance. Furthermore, it may be often noticed that galvanization of the pneumogastric nerves does not appear to diminish the contractile power of the heart, though it suspends its manifestation. For after the galvanization is stopped, and the heart's action begins again, the contractions of the organ are quite as powerful as ever, and even seem to have acquired a greater force during the period of repose.

These phenomena, therefore, cannot be entirely explained by attributing a directly sedative influence to the pneumogastric nerve.

Various other explanations have been offered by different observers, in order to account for the singular phenomena which we have just witnessed. It has been thought by some that the galvanization of the pneumogastric nerves acts by exciting contraction in the blood-vessels ramifying in the tissue of the organ. These vessels, accordingly, being spasmodically contracted and emptied of their contents, the natural stimulus of the blood is withdrawn from the muscular fibres of the organ, and they therefore cease to contract. On the other hand, when the pneumogastrics are divived or tied, the capillary vessels and small arteries of the heart are supposed to be paralyzed and dilated. A larger quantity of blood than usual is thus allowed to accumulate in the tissue of the heart, and its muscular fibres consequently contract oftener than before.

I do not know that there are any direct proofs in favor of this explanation. If it were correct, the heart would necessarily be in an anæmic or exsanguine condition during the suspension of its movements by galvanization; but its appearance does not usually indicate this to be the case.

Milne Edwards has proposed another and quite different theory

from that just mentioned. He believes that there is in the living body a certain vital activity or force pervading the different organs, and manifesting itself in the vital phenomena. He believes, also, that there is a kind of balance or unstable equilibrium between the quantities of this force residing in different parts; so that if it be suddenly increased in any one organ, the superabundance of force, so generated, will flow outward towards the neighboring parts; and, on the other hand, if it be suddenly exhausted or expended in any part, a compensating flow of nervous force will take place towards that point, causing a diminution of vitality in the adjacent organ, or those in immediate nervous connection with it. When a stream of galvano-electricity, accordingly, is passed through the medulla oblongata or the pneumogastric nerve, it is supposed to exhaust momentarily the nervous vitality at the point indicated; and a corresponding drain is made upon the heart, to compensate for this loss, and the cardiac movements are therefore diminished in rapidity. If the galvanization of the medulla, or of the nerve, be excessive, so great a diminution takes place in the vitality of the heart, that its pulsations are arrested altogether.

This theory, proposed by Milne Edwards, is an ingenious one, and would be quite satisfactory if there were no other facts to be considered. But, unfortunately, it fails altogether in explaining the principal anomaly of the phenomena in question. For what we find most difficult to understand is this: *Why does galvanization of the pneumogastric act upon the heart in a different way from that in which galvanization of the same or other nerves acts upon other muscles?* Galvanization of a nerve, in general, does not exhaust the nervous force, as a primary effect, but excites it. If we subject the sciatic or the facial nerve to even a very powerful current of electricity, the effect is to produce instant contraction in all the muscles connected with it; and exhaustion only follows as a secondary consequence, after the nerve has been repeatedly excited by continued and violent stimulus. Besides, the pneumogastric nerve itself, when galvanized, excites contraction, as I have already mentioned, in the other muscular organs to which it is distributed, and produces relaxation only in the heart.

The various theories, therefore, which have been proposed in connection with this subject, are none of them quite satisfactory; and we shall perhaps be obliged to rest contented with knowing the bare fact that the heart acts in this peculiar manner, and is influenced, as we have seen, by the galvanization of its nerves.

If I were to offer, however, an explanation of my own to account for these peculiarities, it would be as follows: I believe, as already

intimated, that the phenomena in question do not depend upon any peculiar action of the pneumogastric nerve, but upon a peculiarity in the physiological organization of the heart itself. The pneumogastric does not act differently from other nerves, but the heart acts differently from other muscular organs.

In the first place, division of the pneumogastric nerve in reality diminishes the action of the heart. It is true that the cardiac pulsations are more frequent after section of the nerve; but it is also true that they are less powerful. This fact has been noticed repeatedly by experimenters, and is at least equally important with the other. We have here, therefore, two results following upon section of the pneumogastrics. First, diminution in the force of the heart's pulsations; second, increase in their frequency. These two phenomena, in fact, almost invariably accompany each other, whatever may be the exciting cause upon which they depend. In most pathological conditions, as well as in physiological experiments, we find that an enfeebled condition of the heart is accompanied by an unusually rapid pulsation. The increased rapidity of pulsation, therefore, after division of the pneumogastrics, is simply in consequence of a diminution in the power of the heart; and is to be regarded as a secondary symptom, not as an immediate effect of the operation.

On the other hand, galvanization of the pneumogastric diminishes the frequency of the heart's pulsations, and if sufficiently intense suspends them. But at the same time, the cardiac contractions, though slower than usual, are more powerful while under the influence of the galvanization. This increased force of the heart's action may sometimes be appreciated by the eye when the organ is exposed to view; and after its pulsations have been suspended for a time by a powerful galvanic current, they may be seen to recommence, as I have already mentioned, with greater force and vigor than before. Now, the heart, as we know, has the power of contracting at regular intervals by virtue of its own force or physiological constitution. And this force, which is generated in the heart by its own nutrition, is discharged or expended at each effort of contraction. The contractile power of the organ, therefore, which is discharged at each pulsation, accumulates in the intervals of contraction. I believe that galvanization of the pneumogastric nerve increases directly the contractile power of the heart; and that it diminishes the frequency of the pulsations, because it stimulates the nutritive process which takes place in their intervals.

In point of fact, when the heart is vigorous and powerful, it always pulsates slowly; and when enfeebled by injury or disease, it pulsates

more rapidly. However we may explain it, it is certainly true that when the entire system is in its most healthy and efficient condition, the heart's pulsations are comparatively slow, steady, and powerful; and an increase in force is naturally accompanied by a diminution in the rapidity of its action. We may suppose, therefore, that when galvanization of the pneumogastric nerve diminishes the frequency of the heart's pulsations, and at the same time increases their force, it only acts in the same way with any other cause which might stimulate the nutrition of its tissue.

But we will now leave these theoretical discussions, and pass to the consideration of certain poisons, and the influence which they exert upon the heart's action.

The tendency of most of the *narcotic* poisons is to stop respiration without affecting directly the movements of the heart. We know that opium, more particularly, has this effect. If a patient be suffering from an overdose of opium, or any of its preparations, one of the most striking symptoms is retardation of the respiratory movements. If the dose be excessive, the respirations will gradually fall from eighteen to ten, six, five, and even four per minute. If the narcotism be carried beyond this point no hope of recovery exists, except in the employment of artificial respiration. The heart, during this time, suffers but little. Its pulsations continue, and will continue, if the respiratory movements do not fail from the action of the narcotic. If artificial respiration, accordingly, be kept up for eight, ten, or twenty-four hours, as the case may be, the effect of the poison during this period gradually wears away. The natural movements of respiration then recommence, and the patient recovers.

But there are some poisons which seem to act more immediately and directly upon the heart itself; and among these I believe to be the anæsthetic agents, *ether* and *chloroform*.

It is very true that both these substances will sometimes produce a stoppage of respiration without arresting the motion of the heart. But in these instances the stoppage of respiration is merely temporary; and is simply due to the profound state of anæsthesia which has been produced. In a few seconds the excessive narcotic influence is abated, and the animal begins breathing again, without having suffered any permanent injury. It is very curious to see the respiratory movements recommence spontaneously after they have been stopped by ether or chloroform, the pulsations of the heart continuing all the while without interruption.

These are the ordinary effects of the anæsthetic agents. But be-

sides this, they are liable also to exert a specific poisonous action, by paralyzing the heart. Now, we know that if respiration be stopped, and the heart continue to pulsate, recovery will take place. But if the heart stops, it will do no good to keep up the respiration, and the animal necessarily dies. In all cases where death follows from the influence of the anæsthetics, experiment shows that the fatal effect is due to a direct and sudden paralysis of the heart.

This effect is infinitely more apt to take place with chloroform than with ether; but it may be produced with either of these anæsthetics, at least in operating upon small animals.

In order to show the influence of ether in producing paralysis of the heart, I will etherize these two cats. In one of them the etherization will be simply carried to the point of insensibility; in the other it will be so given as to produce, if possible, a fatal effect.

I now etherize the first animal. He struggles little at first, but soon becomes more quiet, and is now under the influence of the anæsthetic. The movements of respiration, you observe, are exceedingly quiet and regular. The heart's pulsations are rapid, but otherwise quite natural and vigorous.

I will now break up the medulla oblongata in this animal, by introducing a steel instrument through the foramen magnum. You see the respiratory movements instantly cease. I now proceed to open the chest rapidly and expose the heart to view. The organ, you observe, is still pulsating, and pulsating with a great deal of vigor. These pulsations will undoubtedly continue for several minutes, notwithstanding the double influence of the administration of the anæsthetic, and the violent stoppage of respiration. You can even repeat here, the observations which we made at the last lecture, on the swelling of the heart and the distention of its cavities after suspension of respiration. You see that the accumulation of blood is beginning to take place, and that the pulsations are becoming labored in character. It is now a minute and a half since the medulla was destroyed, and fully a minute since the chest was opened; and yet the cardiac movements continue with a great deal of regularity, and will evidently continue, in some sort, for a considerable time longer. It is only at the end of three minutes that they begin to be irregular, and show the approaching condition of over-distention and paralysis.

It is evident, therefore, that in this instance the ether did not exert any directly poisonous effect on the heart.

Now, in this second animal, I endeavor to administer the ether so as to produce death. By a prolonged and excessive anæsthesia, we

can at almost any time produce a fatal result, in the smaller animals; but this accident often happens, especially in the employment of chloroform, without our expecting it, and from some cause which we cannot readily explain. In this instance, you will observe, I take pains not to prevent the free access of atmospheric air; I wish merely to produce a thorough and complete action of the anæsthetic vapor, unmixed with any influence of obstructed or deficient respiration.

On feeling the walls of the chest, I find that the heart still continues to pulsate with its usual regularity. The respiration, which was suspended for a moment, immediately recommences. But, on continuing the etherization, the respiratory movements become less forcible than before. I feel the chest still expanding and collapsing regularly, but more feebly. The heart's pulsations, also, are less powerful, though rapid. You observe, at this time, some spasmodic movements of the voluntary muscles, which, however, are soon over. The heart has stopped; or at least, its pulsations can no longer be felt through the walls of the chest.

I will now open the chest as rapidly as possible, and expose the thoracic organs. You observe the contractions of the heart continue, but they are infinitely less powerful than in the other instance. In fact, notwithstanding the difference in time which has elapsed since the chest was opened, in the two animals, you see there is not much, if any, difference in the action of the heart. In both, the cardiac pulsations are now excessively feeble; but in the first cat, they are still nearly or quite equal, in force and regularity, to those in the second; and they finally come to an end in both at nearly the same moment.

In the former instance, the heart stopped simply on account of the suspension of respiration; in the second case, it was directly paralyzed by the influence of the ether.

There are two other poisons, which have a very different effect upon the heart, to which I will finally direct your attention. These are *hydrocyanic acid* and *woorara*. Hydrocyanic acid acts in very much the same manner as ether and chloroform, only more promptly and certainly; that is, it suspends directly the action of the heart. This is to be seen very distinctly in the frog, and other reptiles, in which the action of the heart is naturally very persistent. Here, for example, is a frog, in which I break up the medulla oblongata, and then cut away the parietes of the chest, so as to expose the heart. You see that the organ continues to pulsate with almost its accustomed

regularity; its action not being so closely dependent on respiration, as in the warm-blooded animals.

Here, however, is a frog which has been poisoned with hydrocyanic acid. On cutting away the walls of the chest, you see that the heart is perfectly motionless. It has been paralyzed by the action of the poison.

Woorara, on the other hand, has a very different action. If a dog be poisoned by injecting a small quantity of this substance in solution into the blood-vessels, or into the areolar tissue, the first effect of its operation is to produce a partial paralysis of the voluntary muscles. The animal is suddenly affected with a trembling of the limbs, accompanied with stumbling and irregularity in the gait. He soon after falls powerless upon the floor, and the paralysis of the voluntary muscles becomes complete. In a short time it begins also to affect the muscles of respiration, and the respiratory movements become more and more imperfect, and at last cease altogether. During this time there is no sign of pain, and no convulsions, but there is simple paralysis of the motor nerves, and a consequent want of action in the muscles. Woorara, however, exerts no direct action upon the heart. The cardiac pulsations not only continue, but remain quite as powerful after poisoning with woorara as before. In the warm-blooded animals, accordingly, we can maintain the action of the heart by artificial respiration, and thus study its movements for an indefinite length of time.

Here, gentlemen, you see a frog, which has been poisoned with woorara for the last two hours. The animal is, to all appearance, completely dead. There is no sign of consciousness, no voluntary movement, no reflex action. But on opening the chest, you see the heart is still performing its regular alternate movements of contraction and relaxation.

You will notice, also, in these two frogs, another peculiarity which distinguishes the action of the two poisons. In the frog killed by hydrocyanic acid, though the heart has stopped, the blood is everywhere of a scarlet color; and the heart, as well as the tissues generally, has a bright rosy color. This seems to depend upon a specific effect of hydrocyanic acid upon the blood. In the frog poisoned with woorara, on the other hand, the blood is everywhere of a dark venous hue, from want of respiration; and the heart and all the tissues present a dusky bluish or leaden tinge.

There are several varieties, however, of this curious poison which are so different in their mode of operation, that I will ask your attention to some of the most remarkable. Here is a specimen which came from

South America, only a year or two ago. It acts by stopping the voluntary movements, destroying, at the same time, consciousness, volition, sense, and particularly the movements of respiration—everything, in fact, but the action of the heart. Most kinds of woorara which have been used for experiment act precisely in this way. I have here a specimen which was given me by Dr. John W. Greene. It was brought from South America, nearly twenty years ago, and still retains its original vigor. It destroys all volition and consciousness, but leaves the action of the heart undisturbed.

Here is another specimen, which was brought from Venezuela in 1858, and which I obtained through the politeness of Dr. E. Acosta. This has also the effect of stopping all voluntary motion, but, so far as I can judge, does not interfere, to the same extent, with sensation and consciousness; so that although the animal cannot struggle, he still seems capable of feeling pain to a considerable degree. These differences in the action of the poison may account for the various results which different experimenters have met with, in using it. It is not at all unlikely, indeed, that there may be as many different kinds of woorara as there are tribes of Indians who manufacture it.

Here is a gourd, filled with the poison, as it is prepared by the natives. It is sometimes put up in this way, sometimes in little stone jars, sometimes smeared on the outside of pieces of reeds.

I have here, however, another variety of woorara, which is exceedingly remarkable, and differs from all the others in its mode of operation. It is a kind called by the natives "Corroval." I am indebted for this specimen to the kindness of Dr. Wm. A. Hammond, of the United States Army, who received it from South America. It is said to have been obtained originally from the River Darien, in New Granada.

The Corroval seems to act in a precisely opposite manner to the other varieties of woorara. The rest, as we have seen, paralyze the voluntary muscles, but leave the heart unaffected. This, on the contrary, stops the action of the heart, and has little or no direct influence on the voluntary motions. Dr. Hammond has found that in frogs the heart stops beating in from five to seven and a half minutes after the inoculation of the poison; while the voluntary motions continue for twenty to twenty-five minutes, and reflex movements for over three-quarters of an hour. He regards the cessation of the voluntary and reflex movements, therefore, as a secondary consequence only, and considers that the direct action of the poison is exerted upon the heart itself.

Here are two frogs, which were poisoned, a few moments before the lecture commenced, by this variety of woorara. You see that in both these animals the pulsations of the heart have entirely ceased. I will now inoculate another frog with the same kind of poison, and we will then see the rapidity with which this effect is produced. I will first break up the brain and medulla oblongata, so as to destroy all consciousness and voluntary motion; and then, after opening the chest, you see the heart still beating regularly, in its normal position. An incision is then made in the back, and a small quantity of corroval, in solution, injected beneath the integument. At the same time, in order to observe the comparative effects of this poison, I will break up the brain and medulla in another frog, and after cutting open the chest, allow both animals to remain with the heart exposed.

At the end of a minute and a half, you already see a sensible diminution of the cardiac movements, in the poisoned frog. The pulsations grow less and less active, as the poison continues to be absorbed. They have now entirely ceased, while in the other animal the heart's action continues as regular and vigorous as before.

Such is the action of some of the most important varieties of poison upon the action of the heart. At the next lecture we shall pass on to the study of the arteries and the arterial circulation.